Naval Education and Training Command

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Training Manual (TRAMAN)

Quartermaster 1 & C

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Naval Education And Training Program Management Support Activity

QUARTERMASTER 1 & C

NAVEDTRA 12122

1991 Edition Prepared by
QMC(SW) Stephen J Abrams and
QMCS(SW) Irvin E. Nystel

PREFACE

This training manual (TRAMAN) and the two separate nonresident training courses (NRTC) comprise a self-study program for Quartermaster (QM) First and Chief rates.

Designed for individual study, the TRAMAN provides subject matter that relates directly to the occupational standards of the QM rating. The NRTCs provide the usual way of satisfying the requirements for completing study of the TRAMAN. The assignments in the NRTCs are designed to lead students through the TRAMAN.

This training manual and its associated NRTCs were developed by the Naval Education and Training Program Management Support Activity, Pensacola, for the Chief of Naval Education and Training. Technical assistance and review were provided by Fleet Training Center (FTC), Norfolk, Virginia; Defense Mapping Agency, Hydrographic/Topographic Center, Washington, D.C.; Naval Oceanography Command, Stennis Space Center, Mississippi; and Fleet Area Control and Surveillance Facility, Virginia Beach, Virginia.

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THE UNITED STATES NAVY

GUARDIAN OF OUR COUNTRY

The United States Navy is responsible for maintaining control of the sea and is a ready force on watch at home and overseas, capable of strong action to preserve the peace or of instant offensive action to win in war.

It is upon the maintenance of this control that our country's glorious future depends; the United States Navy exists to make it so.

WE SERVE WITH HONOR

Tradition, valor, and victory are the Navy's heritage from the past. To these may be added dedication, discipline, and vigilance as the watchwords of the present and the future.

At home or on distant stations we serve with pride, confident in the respect of our country, our shipmates, and our families.

Our responsibilities sober us, our adversities strengthen us.

Service to God and Country is our special privilege. We serve with honor.

THE FUTURE OF THE NAVY

The Navy will always employ new weapons, new techniques, and greater power to protect and defend the United States on the sea, under the sea, and in the air.

Now and in the future, control of the sea gives the United States her greatest advantage for the maintenance of peace and for victory in war.

Mobility, surprise, dispersal, and offensive power are the keynotes of the new Navy. The roots of the Navy lie in a strong belief in the future, in continued dedication to our tasks, and in reflection on our heritage from the past.

Never have our opportunities and our responsibilities been greater.

CONTENTS

CHAPTER 1

COMPASSES

You have gained a basic working knowledge of magnetic and gyrocompasses from your study of the *Quartermaster 3* and the *Quartermaster 2* training manuals, A school, or on-the-job experience. As you advance in rate, you will be required to determine magnetic compass error and to prepare deviation tables. You will also be required to identify errors in the gyrocompass system. This chapter thoroughly examines the development of deviation tables and discusses errors in the gyrocompass system that have not been covered before. Also discussed is the gyrocompass system, with an introduction to magnetic compass adjustment.

After studying the chapter, you should be able to (1) prepare magnetic compass deviation tables and (2) identify procedures for magnetic compass adjustment.

MAGNETIC COMPASS

The CNO has established the requirement that each self-propelled ship and service craft of the United States Navy except submarines be equipped with one or more magnetic compasses suitable for navigation. All surface ships and craft, regardless of size or classification, are provided with a magnetic steering compass at the primary steering station.

Most ships carry only one magnetic compass, called the steering compass. It is normally in the ship's pilothouse located on centerline (except aboard aircraft carriers) where it can best be seen by the helmsman. The indications of the steering compass are *per steering compass* (PSTGC). If a ship has two magnetic compasses, the second compass is called a standard compass and is usually the most accurate magnetic compass aboard ship. It is normally located on the ship's centerline at a point where it will be least affected by unfavorable magnetic influences. The indications of the standard compass are expressed as *per standard compass* (PSC).

COMPASS NOMENCLATURE

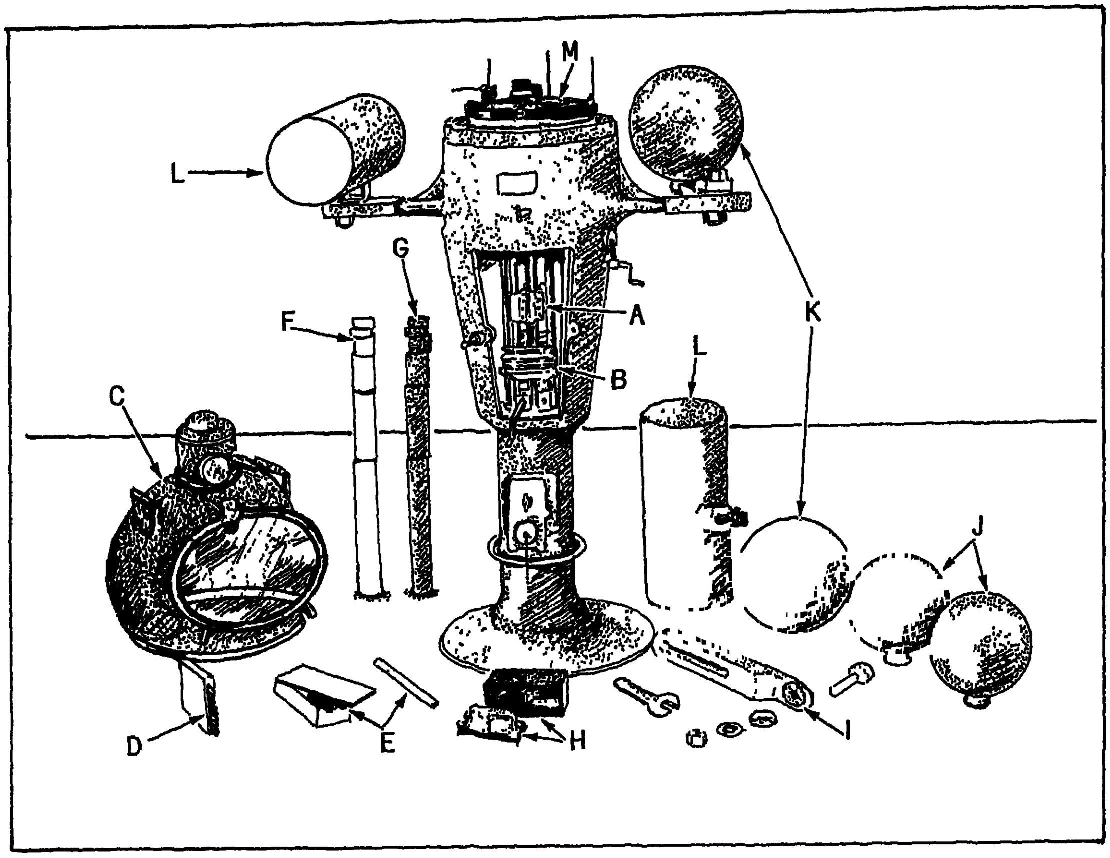
In the *Quartermaster 3* training manual, you learned the major parts of a magnetic compass. For compass correction, you must be familiar with many additional components, the principal one of which is the binnacle. The compass is housed in a binnacle. A binnacle may vary from a simple wooden box to an elaborate device of bronze or some other nonmagnetic material. Most binnacles provide a means for housing or supporting the various objects used to adjust the compass. In some older binnacles used by the Navy, the equipment used to compensate for deviation caused by degaussing is also housed in the binnacle.

The two compasses used most by the United States Navy are the No. 1 (7 1/2-inch) and the No. 3 (5-inch) magnetic compasses. Figures 1-1A and 1-1B show the parts of the binnacles used to house these compasses. The purpose of most of the parts listed, as well as their actual use and physical placement, is discussed later in this chapter.

LIMITATIONS OF THE MAGNETIC COMPASS

The magnetic compass, as you know through experience, is a reliable instrument. Normally, it must be severely damaged or destroyed to make it completely inoperable. The magnetic compass is not a perfect instrument, however, and it does have some drawbacks. Many shortcomings are discussed in the current *Quartermaster 3* training manual (*QM3* TRAMAN), and they are not mentioned further here.

One of the limiting factors of a magnetic compass not stressed in the *QM3* TRAMAN is that only the horizontal component of Earth's magnetic field exerts a directive force on it. This force is greatest at the magnetic equator; and as the distance from the magnetic equator increases, the angle of dip becomes greater, resulting in a



A. Trays for fore-and-aft magnets
B. Trays for athwartship magnets
C. Binnacle hood
D. Magnets for fore-and-aft and athwartship trays
E. Heeling magnets
F. Flinders bar spacers
G. Flinders bar
H. Dip needle
I. E-link
J. 7-inch spherical quadrantal correctors
K. 9-inch spherical quadrantal correctors
L. Cylindrical quadrantal correctors
M. Compass with azimuth circle

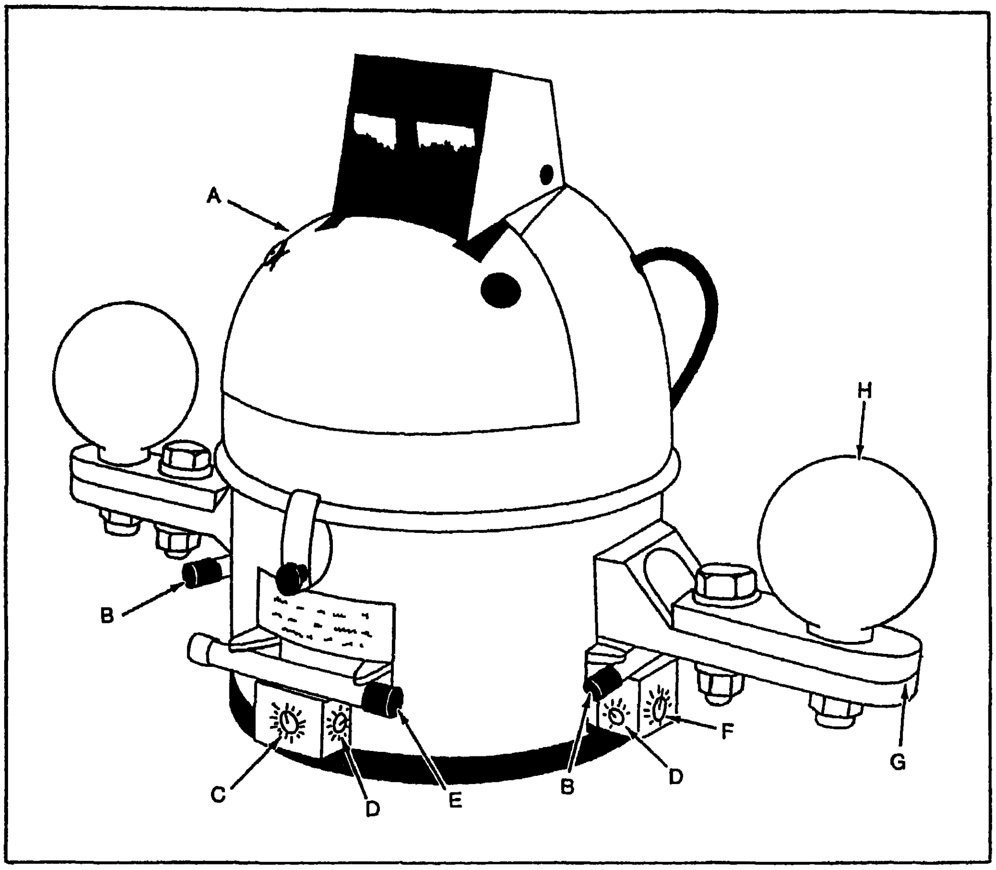
112.2

Figure 1-1A.—No. 1 compass binnacle and correctors.

decreasing effect of the horizontal component. Within a few hundred miles of the magnetic poles, the magnetic compass becomes sluggish; and over the magnetic poles, it loses its directive force altogether. With increased operations in polar regions, the inadequacy of the magnetic compass becomes a matter of prime importance. Chief reliance must be placed on the gyrocompass in higher latitudes. The magnetic compass is unreliable in latitudes greater than 70°.

TYPES OF DEVIATION

From prior studies, you will recall that magnetic compass accuracy is affected by variation and deviation errors. Variation can only be identified and compensated for. Deviation, however, can be identified, compensated for, and/or adjusted to reduce, if not eliminate, the error it causes. Variation, the difference between the geographic North Pole and the magnetic north pole, is precalculated and annotated on most navigational charts used by the Navy, and will not be discussed further. Although mechanical errors are least likely to occur, their identification and removal or repair are just as important as other compass errors. Routine specific inspection of the magnetic compass for mechanical or corrosion deficiencies and inspection of the area surrounding the compass for errantly placed



A. Lighted hood
B. E/W coarse corrector
C. E/W (vernier) fine corrector
D. Fine corrector locking screw
E. N/S coarse corrector
F. N/S (vernier) fine corrector
G. Quadrantal sphere adjusting arm
H. Quadrantal sphere

Figure 1-1B.—No. 3 compass binnacle and correctors.

magnetic influencing equipment or supplies can minimize or prevent mechanical errors.

The magnetic properties of your ship cause a deviation error in the magnetic compass. Ship magnetism is of two types. First, there is permanent magnetism (magnetism in steel or hard iron, which acts as a permanent magnet). Second, there is induced magnetism (magnetism in soft iron, which is only temporary and is changing constantly, depending upon ship's heading and latitude).

You may become confused by the terms *north magnetism* and *south magnetism* when deviation is discussed in the following topics. This confusion can be avoided and the following illustrations more easily understood if you remember these points:

— Earth's magnetism in the Northern Hemisphere is called blue magnetism;

— Earth's magnetism in the Southern Hemisphere is called red magnetism;

— the north-seeking end of a bar magnet has red magnetism; and

— the south-seeking end of a bar magnet has blue magnetism.

PERMANENT MAGNETISM

Because the majority of ships are built of magnetic material that is continually under the

influence of a magnetic field, they acquire some permanent magnetism. For example, let's say that the ship in figure 1-2 was built in the Northern Hemisphere at a northwest magnetic heading. No matter how the ship is turned, the distribution of permanent magnetism is always the same. However, the amount of permanent magnetism may undergo rapid changes after building. The changes will be most notable immmediately after launching and during the first few months of operation. The compass error changes as the amount of magnetism changes.

Permanent Magnetism Components

Permanent magnetism has both vertical and horizontal components. The magnetic compass is designed to respond to horizontal forces only. The vertical component of permanent magnetism does not cause deviation as long as the ship remains on an even keel. When the ship rolls or pitches, the vertical component causes an unsteadiness in the compass. The compass is also affected if the ship has a permanent list. The compass error produced by rolling, pitching, or listing is called heeling error. The correction for heeling error is discussed later in this chapter.

Deviation due to uncorrected permanent magnetism varies with each change in latitude. The horizontal intensity of Earth's magnetic field

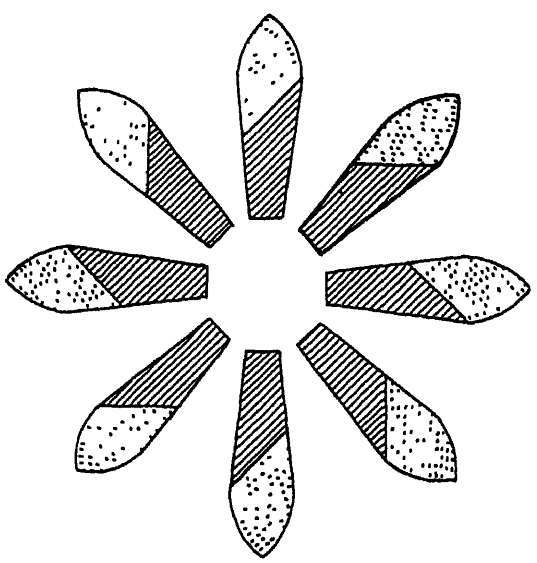


Figure 1-2.—Magnetism in a ship built on a northwest heading.

decreases as your ship moves farther from the magnetic equator. Consequently, the magnetic force acting on the ship changes, and the deviation varies accordingly.

When your ship proceeds toward the magnetic equator, the uncorrected deviation caused by permanent magnetism decreases; therefore, it increases when your ship proceeds toward either of the magnetic poles. In other words, when you are traveling near the equator, the magnetic compass is most accurate. The deviation is greatest and the magnetic compass least accurate when you are near the poles.

Correcting Deviation Caused by Permanent Magnetism

A large single bar magnet could be placed near the magnetic compass to neutralize the effects of the ship's magnetism. However, this method presents too many practical difficulties and is not used. Correction must be made separately for both the fore-and-aft and athwartship components of permanent magnetism. This correction is made by placing magnets in the compass binnacle. See figures 1-1A and 1-1B. The fore-and-aft magnets are inserted and adjusted when your ship heads magnetic east or west. Athwartship magnets are inserted and adjusted when your ship heads magnetic north or south. The deviation caused by permanent magnetism is reduced by means of the permanent magnets.

To see how the correction might be made, look at the ship in figure 1-3. In view A of the illustration, the ship is heading magnetic north. The permanent magnetism of the ship is indicated by the red and blue poles marked with the letter *P*. Small poles marked *Pb* and *Pc* represent the fore-and-aft and athwartship components of the permanent magnetism. The fore-and-aft component, *Pb*, has no effect on the compass. Permanent magnets are placed athwartships to correct the deviation caused by component *Pc*.

In view B, the ship is heading magnetic east, and you can see that *Pc* has no effect. Permanent magnets are then placed fore and aft to correct the deviation caused by component *Pb*.

INDUCED MAGNETISM IN VERTICAL SOFT IRON

You already know that Earth's magnetic field induces a certain amount of magnetism in the iron and steel of a ship. This magnetism induced in the vertical structures of your ship, such as

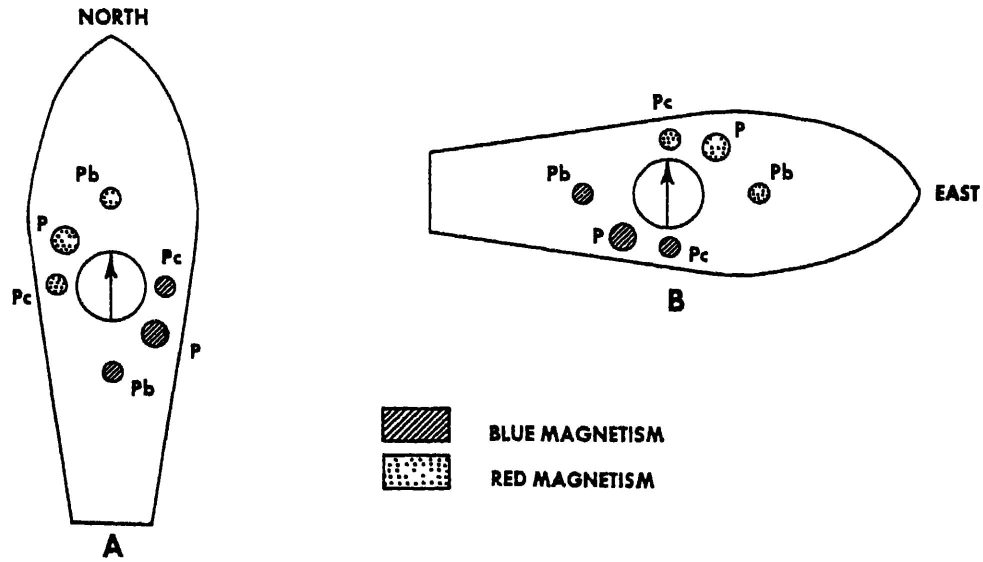


Figure 1-3.—Correcting permanent magnetism.

bulkheads and stanchions, is called induced magnetism in vertical soft iron. It is so named because the effect is most notable in soft iron, even though induced magnetism is present in both soft and hard iron. The vertical component of the field is greatest at high latitudes. This means the magnetism induced into vertical soft iron is greatest at the poles. Near the magnetic equator the vertical component of Earth's magnetic field is small, so there is very little vertical induced magnetism. This means that the induced magnetism in vertical soft iron is least at the equator.

You must make a distinction between the poles of the ship's permanent magnetism and the poles of induced magnetism. The exact location or position of the poles of the ship's permanent magnetism is different on practically every ship. This depends largely upon the heading on which the ship was built. Your sister ship may be identical to your ship in every respect to the amount or concentration of iron or steel. More than likely, however, if it was built in ways of a different heading from your ship, its concentration or poles of permanent magnetism differ from those of your ship. The intensity of permanent magnetism does not change with changes of latitude.

Effect of Latitude Change on Induced Magnetism

In the majority of steel ships, the poles of magnetism induced in vertical soft iron are located on the fore-and-aft centerline of the ship. This is true regardless of the heading on which the ship was built. Induced magnetism on all ships varies in intensity with changes of latitude.

For the reasons stated previously, uncorrected deviation due to magnetism induced in vertical soft iron changes with every change in magnetic latitude. The horizontal intensity of Earth's magnetic force increases when proceeding toward the magnetic equator. This increased intensity causes a greater force on the compass needle and pulls in line with the meridian. The actual strength of the pole of induced magnetism in vertical soft iron decreases as your ship proceeds toward the magnetic equator. The actual strength of the pole of induced magnetism in vertical soft iron increases as your ship proceeds toward the magnetic poles. The complete absence of a vertical magnetic field at the magnetic equator leaves no induced magnetism in the vertical soft iron of the ship. If your compass is adjusted at the magnetic equator and the permanent magnetism remains constant, any deviation when you are on an east or west heading after leaving the magnetic equator can be attributed to vertical magnetism alone.

Correcting Deviation Due to Vertical Soft Iron

Adjustment for deviation caused by induced magnetism in vertical soft iron on the No. 1 (7 1/2-inch) compass binnacle is made by placing

a metal bar (in which magnetism can be induced) near the magnetic compass. This metal rod or corrector is called a Flinders bar. See figure 1-1A. The Flinders bar consists of several segments of various lengths. It is inserted in a holder mounted on the binnacle. Wooden or brass fillers come in segments the same lengths as the Flinders Bar. They are inserted in the bottom of the holder so that the top of the Flinders bar is even with the top of the holder. The top of the holder for the Flinders bar is exactly 2 inches above the plane of the compass card. Because the pole of vertical induced magnetism is usually abaft the compass, the Flinders bar is normally mounted on the forward side of the compass binnacle.

The No. 3 (5-inch) compass binnacle does not have a Flinders bar; therefore, this correction cannot be made to the No. 3 compass binnacle.

INDUCED MAGNETISM IN SYMMETRICAL, HORIZONTAL SOFT IRON

Compasses are located on the amidships line on ships that have both the standard compass and the steering compass. This causes the steel and iron to be arranged uniformly and symmetrically around the magnetic compass. As a result, the compass is surrounded by an equal distribution of soft iron in which magnetism can be induced horizontally. This induced magnetism occurs mainly in the bulkheads and decks of your ship. The bulkheads and decks, then, can be considered to be horizontal induced magnets.

The horizontal induced magnetism can be visualized as two magnets, one of the magnets running fore-and-aft and the other running athwartships. The fore-and-aft magnet can be induced easier by magnetism than the athwartship magnet. The athwartship magnet has its poles closer to the magnetic compass, so it has a much greater effect on the compass. For simplification, only the effect of the athwartship magnet is considered in this text.

Effect of Heading Change on Induced Magnetism

From figure 1-4 you can see there is no deviation when the ship is at a cardinal heading.

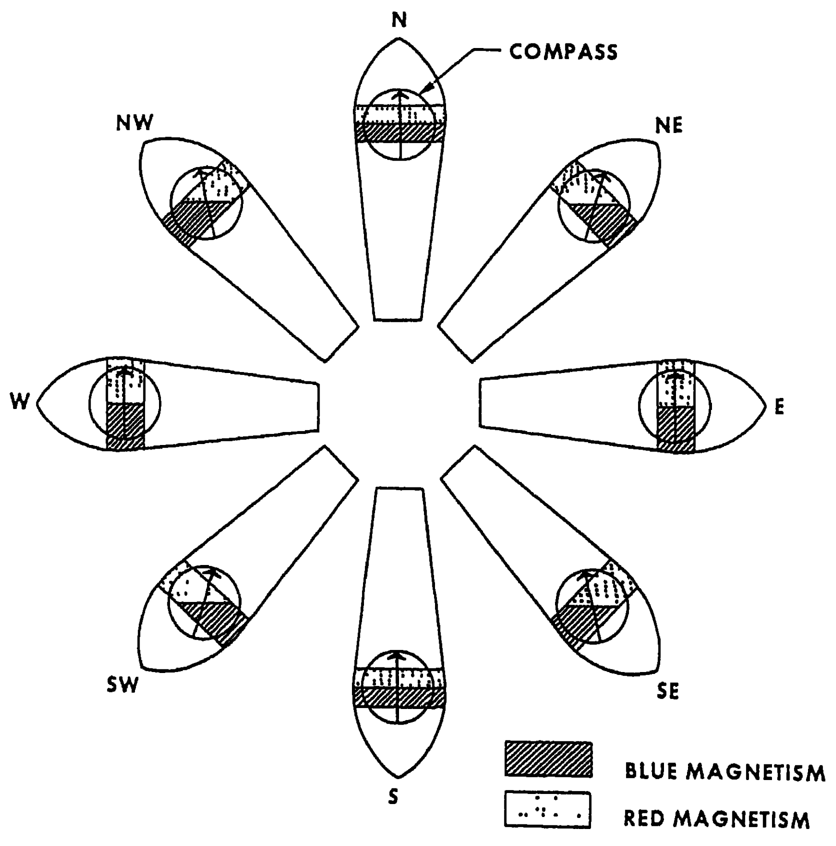


Figure 1-4.—Quadrantal deviation.

At all other headings, there is deviation. You will notice, also, that deviation is easterly at headings NE and SW. When you are heading SE or NW, the deviation is westerly. As you can see, the deviation changes direction with every 90° change of heading. This is caused by induced magnetism in horizontal soft iron. It is called quadrantal deviation. Uncorrected quadrantal deviation does not usually change with a change in latitude.

Correcting Quadrantal Deviation

Quadrantal deviation is corrected by means of two hollow spheres of soft iron, called quadrantal spheres. These correctors are usually installed one on either side of the magnetic compass on the athwartship line through the compass. See figures 1-1A and 1-1B.

Earth's magnetic field magnetizes these spheres by induction. The induced magnetism of the spheres counteracts the induced magnetism of the ship. This forces the compass needle to align itself with the magnetic meridian. When quadrantal spheres are in use, deviation may change with latitude, because of induction in the spheres.

The magnetic force exerted by the spheres can be altered by changing their distance from the compass. It can also be altered by changing the size of the spheres to a larger or smaller size. These spheres are extremely effective in correcting quadrantal deviation on all headings.

The following procedure is the best method to adjust the quadrantal spheres to correct the magnetic compass for quadrantal deviation. Head the ship on all four of the intercardinal points, obtaining the average of the deviations of these four points, and remove this amount on only one of the intercardinal headings.

HEELING ERROR

All adjustments for deviation thus far were made on the assumption that your ship has been on an even keel. When your ship heels to one side or the other, the metal of the ship changes its relative position with respect to the magnetic compass. This happens because the compass is mounted in gimbals and remains horizontal. The main causes of heeling error are vertical permanent magnetism, vertical induced magnetism, and horizontal induced magnetism.

In view A of figure 1-5, you see the magnetism of horizontal soft iron in a ship on a north heading. There is no deviation initially. But when

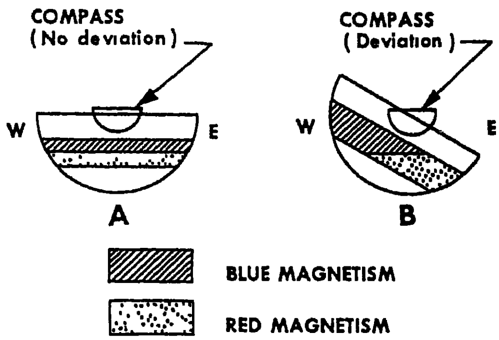


Figure 1-5.—Heeling error.

the ship heels (view B), the poles are realigned east and west, and this causes deviation.

Heeling error is maximum on north and south headings. As the ship heels, the poles of induced magnetism lie to the east and the west of the compass. This causes deviation. On an east or a west heading, the poles are in line with the compass magnets. This merely increases or decreases the directive force on the compass. Heeling error on east or west headings is caused more by the pitch of the ship than by list or roll.

If your ship has a permanent list, a constant deviation occurs. When your ship rolls, the deviation is first in one direction and then in the other. The unsteadiness, caused by rolling, results in an oscillating compass. Oscillation is undesirable and can be corrected by the proper placement of the heeling magnet beneath the compass. Placement usually is determined by use of a dip needle or the rolling method.

A dip needle is a delicate instrument that registers magnetic influences and measures those influences. The dip needle is essentially a suspended magnetic needle that rotates freely about a horizontal axis. Because oscillation can complicate compass readings, the first steps are performed in port with your vessel on either an east or a west heading or as close as possible. Because heeling error is caused by rolling, pitching, or listing and the dip needle requires a horizontal reference point, you must determine if your vessel is on an even keel. This can be done mathematically following the procedures outlined in H.O. 226, *Handbook for Magnetic Compass Adjustment*. Having determined the even-keel position, you place the dip needle in the proper position and adjust the heeling magnet until the dip needle reads the same as your even-keel calculations.

Having corrected for east and west headings in port, do the corrections for north and south while underway. The most commonly used procedure is called the rolling method. Your vessel must be rolling while this procedure is being performed. The actual process is very simple, although the amount of time can vary from ship to ship, considering the attention to detail and delicacy of your compass. The rolling method is (1) visually observing your compass card on north and south headings, (2) noting the amount of oscillations present, and (3) adjusting the heeling magnet in order to reduce the amount of oscillation to a minimum Complete removal of oscillation cannot be done; therefore, the final adjustment requires averaging the amount to minimize all oscillations.

METHODS OF FINDING DEVIATION

All magnetic compasses are effected by varying degrees of residual deviation. Deviation can, and does, change under certain conditions. Your current deviation table (usually prepared by a contracted expert if your ship is a newly commissioned ship, but more likely by yourself or a predecessor) details many specifics about an individual compass. Because of the many external and internal influences affecting the magnetic compass, *NAVSEA Technical Manual*, chapter 252 lists a tolerance range, which determines acceptable compass operability. The listed range is that the total deviation from all causes must not exceed 3° with the ships degaussing (DG) system off and 5° with the DG system on.

DEVIATION TABLE

Your current ship's deviation table has been prepared in accordance with the tolerance range. Figure 1-6 is a typical deviation table. The amount and type of information provided gives the necessary data required to begin compass correction when needed. The necessity for compass correction is based on many factors. These include normal ship operations, routine evolutions, and scheduled events. You will note that on the back of the table (fig. 1-6), two sections are provided for remarks and recent events. Your responsibility as a senior QM is to make sure the deviation table is up-to-date and filled out properly. Should correcting your compass be necessary, a procedure known as swinging ship, you must make sure all documentation is complete.

Vessel Operations

NAVSEA Technical Manual, chapter 252 has listed a number of typical ship's evolutions that require your compass to be checked against your deviation table for accuracy. This list includes the following:

- Overhaul or any structural changes that are made in your ship; for example, addition of gun mounts, modifications to houses or mast, removal of structures
- Steaming for long periods on the same course or laying alongside the dock on the same heading for long periods of time
- A radical change in magnetic latitude
- Removal or addition of any magnetic material near a magnetic compass
- Deperming and flashing treatment
- Reaching the magnetic equator
- Removal or addition of any cargo of magnetic material
- A heavy gunnery exercise or battle damage
- Installation of major electrical equipment or components in compass vicinity
- Change in setting of compass coil control resistors (changes DG—on deviations)

After any of the preceding events, your ship should be swung in order to obtain a new deviation table. If the deviation obtained is excessive, the magnetic compass should be readjusted.

Magnetic Compass Records

Elements of good navigation practice are the continual comparison of your magnetic compass, while at sea and in port, with your records. These records include the Commanding Officer's daily position reports, Magnetic Compass Record book and Ship's Deck Log. Essentially, periodic record review and comparison will determine how well your compass operations have been and the present operational condition of the compass. Whether a detailed graphing of the various

GNETIC COMPASS TABLE REPORT-SHIPS-3530-2
SHIPS 1104 (REV. 10-57)

S S. VOGELGESANG NO DD 862 (BB, CL, DD, etc.)

PILOT HOUSE ☐ SECONDARY CONNING STATION ☐ OTHER

NACLE TYPE ☐ NAVY STD ☐ OTHER

PASS 7 1/2" MAKE LIONEL SERIAL NO. 12345

E CC COILS K DATE 17 SEPT 1990

EAD INSTRUCTIONS ON BACK BEFORE STARTING ADJUSTMENT

SHIPS HEAD AGNETIC	DEVIATIONS		SHIPS HEAD MAGNETIC	DEVIATIONS	
	DG OFF	DG ON		DG OFF	DG ON
0	1.5W	2.0W	180	2.5E	3.0E
15	1.5W	2.0W	195	2.5E	3.5E
30	1.0W	1.5W	210	3.0E	3.5E
45	1.0W	1.5W	225	3.0E	3.5E
60	0.5W	0.5W	240	2.5E	3.0E
75	1.0E	1.5E	255	2.0E	2.0E
90	1.0E	1.5E	270	1.5E	1.5E
105	1.0E	1.5E	285	1.0E	0.5E
120	1.5E	2.0E	300	0.5W	0.5W
35	1.5E	2.0E	315	1.0W	1.5W
150	2.0E	2.5E	330	1.0W	1.5W
165	2.0E	2.5E	345	1.5W	2.0W

IATIONS ERMINED BY ☐ SUN'S AZIMUTH ☒ GYRO ☐ SHORE BEARINGS

4 MAGNETS RED ☒ FORE ☐ AFT AT 13" FROM COMPASS CARD

6 MAGNETS RED ☒ PORT ☐ STBD AT 15" FROM COMPASS CARD

-7" ☒ SPHERES ☐ CYLS AT 12" ☒ ATHWARTSHIP ☐ SLEWED ° ☐ CLOCKWISE ☐ CTR CLKWISE

LING NET ☒ RED UP ☐ BLUE UP 17" FROM COMPASS CARD FLINDERS BAR ☒ FORE ☐ AFT 16"

LAT 30° 20' N H ☒ LONG ☐ Z 087° 15' W

NED (Adjuster or Navigator) APPROVED (Commanding) S Abrams

VERTICAL INDUCTION DATA
(Fill out completely before adjusting)

RECORD DEVIATION ON AT LEAST TWO ADJACENT CARDINAL HEADINGS

BEFORE STARTING ADJUSTMENT N 5.5W, E 4.0W, S 5.5E, W 6.0E

RECORD BELOW INFORMATION FROM LAST NAVSHIPS 1104 DEVIATION TABLE

DATE 1 APRIL 1988 ☒ LAT ☐ H 31° 45 W ☒ LONG ☐ Z 78°30'W

16" FLINDERS BAR ☒ FORWARD ☐ AFT DEVIATIONS N 4.5W, E 2.0W, S 4.5E, W 3.0E

RECORD HERE DATA ON RECENT OVERHAULS, GUNFIRE, STRUCTURAL CHANGES, FLASHING, DEPERMING, WITH DATES AND EFFECT ON MAGNETIC COMPASSES

ANNUAL SHIPYARD OVERHAUL 10 MAR – 6 AUG 90
DEPERMED NORFOLK NSY: 15 AUG 90
ABNORMAL DEVIATION OBSERVED

PERFORMANCE DATA

COMPASS AT SEA	☐	UNSTEADY	☐	STEADY
COMPASS ACTION	☐	SLOW	☒	SATISFACTORY
NORMAL DEVIATIONS	☒	CHANGE	☐	REMAIN RELIABLE
DEGAUSSED DEVIATIONS	☒	VARY	☐	DO NOT VARY

REMARKS

NONE

INSTRUCTIONS

1 This form shall be filled out by the Navigator for each magnetic compass as set forth in Chapter 24, Part 2, and Chapter 81, Section III, of Bureau of Ships Manual
2 When a swing for deviations is made, the deviations should be recorded both with degaussing coils off and with degaussing coils energized at the proper currents for herding and magnetic zone
3 Each time this form is filled out after a swing for deviations, a copy shall be submitted to the Bureau of Ships A letter of transmittal is not required
4 When choice of box is given, check applicable box
5 Before adjusting fill out section on "Vertical Induction Data" above

NAVSHIPS-1104 (REV 10-57) BACK

Figure 1-6.—Left, deviation table (front), right, deviation table (reverse).

lings is done or a simple verification of lings versus the deviation table, you must it all times aware of your compass operay.

The most convenient method of determining ation and the most commonly used, when at sea, is to check your compass on each 15° heading or swinging of the ship. This is normally done against a properly functioning gyrocompass. Your ship must be on a magnetic heading to determine deviation, so gyro error and local variation must be applied to each true heading. You should work all headings through

to true. See figure 1-7 for an example of how to compute true heading. Some other methods of finding deviation can be found in the *Handbook of Magnetic Compass Adjustment*. We will briefly discuss the basic elements of compass adjustment and swinging ship.

MAGNETIC COMPASS CORRECTION AND PREPARATION

Procedures for magnetic compass correction and adjustment are accomplished in two distinct and separate phases. First, while the ship is in port, physical checks of the compass, binnacle, and associated ship's equipment are done. Necessary data and supporting information are gathered and applied. The second phase, completed at sea, is the final adjustments and an updated documented deviation table.

Because of the complexity and detail involved, you should see the step-by-step procedures for preparation and final adjustments found in chapter 1, "Procedures For Magnetic Compass Adjustment" (Check-off List), of the *Handbook of Magnetic Compass Adjustment*.

Dockside Testing and Adjustments

Dockside Testing and Adjustments, paragraph 101A of chapter 1, the check-off list, has five headings listed that provide you with the complete correction process. This step-by-step procedure, primarily relying on existing records (that is, the Deviation Table and Magnetic Compass Record Book), checking alignments and testing various equipage, is explained in excellent detail. These steps include checking the following recorded information:

- Amount of Flinders bar, and whether the bar is forward or aft of the binnacle.

- Number of fore-and-aft magnets, whether their red ends are forward or aft; the distance, in inches, between the fore-and-aft tray and the compass card.

- Same as the preceding step, but for the athwartships tray.

- Which end of the heeling magnet is up, and its distance from the compass card.

- All your binnacles are as near the amidships line as possible and secured solidly. On the standard 7 1/2-inch compass, the compass bowl must be adjusted by the screws at the ends of the outer gimbal knife edges until it is in the exact center of the binnacle. In this position, with the ship heading north or south, raising or lowering the heeling magnet has no effect on the compass card. The compass should be secured in this position by setting the screws so as to prevent it from sliding back and forth athwartships.

- Exact fore-and-aft position of the lubber's line must be verified by sighting with a bearing circle or an azimuth circle on straightedges erected on the amidships line at some distance forward and abaft the compass. Lubber's lines on peloruses should be checked also. They are checked either by bearings taken simultaneously on a distant object by compass and pelorus, or

To steer magnetic course	With variation	True course	With gyro error	Heading p.g.c. (per gyro compass)
Degrees	*Degrees*	*Degrees*	*Degrees*	*Degrees*
000	6 W.	354	0	354
180	10 E.	190	0	190
270	4 W.	266	1 E.	265
315	6 E.	321	2 E.	319
225	17 W.	208	2 W.	210
358	0	358	3 W.	001

Figure 1-7.—Computing true heading.

by computing (from the ship's plans) the angle the flagstaff or jackstaff should bear from the lubber's line of the pelorus, then verifying the angle by observation.

- The quadrantal spheres and the Flinders bar should be tested for residual magnetism. To test the quadrantal spheres, place them as close to the compass as possible and rotate each one separately. Any change in the compass reading of 2° or more resulting from this rotation indicates residual magnetism in the spheres. To test the Flinders bar, put the ship on an east or west heading. Now invert the Flinders bar in the holder and again note the compass reading. Any difference of 2° or more in the two readings indicates residual magnetism in the Flinders bar. Residual magnetism in either the spheres or bar should be removed by annealing; that is, by heating them to a dull red and allowing them to cool slowly.

- The compass should be completely removed from the ship and taken to a place free from all magnetic influences except Earth's magnetic field for tests of moment and sensibility. To test the compass, use a magnet to draw the compass needle about 1° to the right and observe the reading of the card when it returns to rest. Record the results in your Magnetic Compass Record Book. Repeat the operation, drawing the card to the left. The card should return within 10′; otherwise the compass should be repaired. Oscillation should also be tested and recorded at this time.

- Adjust the heeling magnet, using a balanced dip needle if available at this time.

Swinging Ship

The following are the steps to "swinging ship" at sea and comparing the magnetic compass to a properly functioning gyrocompass. During the initial process the complete removal of all deviation is required, followed by the reducing of observed deviation by half. Remember, the premise is to minimize all deviation effecting your compass, whether residual or induced.

The check-off list in H.O. Pub 226, paragraph 102B of chapter 1, provides a detailed listing of step-by-step procedures. Some of the necessary steps are as follows:

- Adjust the heeling magnet while the ship is rolling on north and south magnetic headings until the oscillations of the compass card have been reduced to an average minimum. (This step is not required if prior adjustment has been made using a dip needle to indicate proper placement of the heeling magnet.)

- Come to a cardinal heading, for example east (090°). Insert fore-and-aft magnets, or move the existing magnets in such a manner as to remove all deviation.

- Come to a south (180°) magnetic heading. Insert athwartship magnets, or move the existing magnets in such a manner as to remove all deviation.

- Come to a west (270°) magnetic heading; correct half of any observed deviation by moving the fore-and-aft magnets.

- Come to a north (000°) magnetic heading; correct half of any observed deviation by moving the athwartship magnets.

Cardinal heading adjustments should now be complete.

- Come to any intercardinal magnetic heading; for example, northeast (045°). Correct any observed deviation by moving the spheres in or out.

- Come to the next intercardinal heading; for example, southeast (135°). Correct half of any observed deviation by moving the spheres.

All intercardinal corrections are performed in the same manner.

The final steps for swinging ship should include the following:

- Secure all correctors before swinging for residual deviations.

- Swing for residual undegaussed deviation on as many headings as desired.

- Record deviations and the details of corrector positions on a new Deviation Table, standard Navy form NAVSEA 3120/4, and in the Magnetic Compass Record Book, NAVSEA 3120/3.

• Swing for degaussed deviations with the degaussing circuits properly energized in accordance with your ship's degaussing folder.

• Record deviations for degaussed conditions on standard Navy form NAVSEA 3120/4.

Upon completion of swinging ship, you must make sure that the results are accurate and in accordance with the previously mentioned tolerance range. Three copies of the deviation are prepared for each magnetic compass. One copy is attached to the binnacle, one copy is maintained in the back cover of the Magnetic Compass Record Book, and one copy is forwarded to Naval Sea Systems Command Detachment (code 6642C), Norfolk, Virginia.

Publications, Charts and Logs

Many assorted references are available for your use when you make compass adjustments and compensations. The *Handbook for Magnetic Compass Adjustment*, H.O. 226, is considered the basic manual for the U.S. Navy. Other excellent sources are the *American Practical Navigator*, H.O. 9, and *Dutton's Navigation and Piloting*, printed by the United States Naval Institute. Each contains detailed explanations of magnetic theory and the applicability common to sea-going vessels and a practical approach to compass adjustment and compensation.

The Defense Mapping Agency Hydrographic Topographic Center publishes a series of magnetic charts of Earth as a whole (Mercator projection) and for the north and south polar areas (azimuthal equidistant projection). Separate charts are prepared for variation (fig. 1-8) and vertical inclination (fig. 1-9) and for intensity of field (horizontal, vertical and total). Of greatest interest to the Navigator is DMAHTC Chart 42, Magnetic Variation Chart of the World (printed for various years).

Your greatest source of information are your ship's logs. Previously mentioned was periodic review of these logs to determine compass and deviation table accuracy. Should your compass develop large deviations and you are unable to perform compass adjustment, the construction of a Napier diagram, also called a Curve of Deviations, is a convenient way of graphically determining intermediate values. The diagram allows you to quickly interpolate between recorded values of deviation. Figure 1-10 is a Napier diagram with curves drawn. Notice that the diagram is divided into two separate elements of north to south and south to north.

The entire range of 360° is covered. Down the center of each column are 360 degrees in 15° increments. The diagonal dotted lines correspond with the 15° increments. The following information is plotted:

Compass		Magnetic	Deviation
N	000°	010°	11°E
NE	045°	047°	2°E
E	090°	085°	5°W
SE	135°	127°	8°W
S	180°	173°	7°W
SW	225°	224°	1°W
W	270°	277°	7°E
NW	315°	327°	12°E

Obviously the excessive values indicate compass adjustment is required, but they serve to illustrate the construction and use of a Napier diagram.

SUMMARY

This chapter is a brief introduction into magnetic theory. Ship's construction, physical and geographic positioning, plus the types and location of construction materials all affect a ship's magnetism. This effect is deviation.

Deviation is divided into two separate categories: permanent and induced. When combined with ship's routine and operations, permanent and induced deviations interact and can severely effect a ship's compass.

Making sure the magnetic compass is operating within the approved tolerance range is one of a senior QM's responsibilities. Therefore, record reviewing and graph compiling should be done to determine if abnormal trends are developing.

Compass correction, if required, is divided into two separate phases: in port and at sea. H.O. Pub 226 is the U.S. Navy standard for magnetic compass correction. The listed procedures must be followed to ensure complete and proper adjustment.

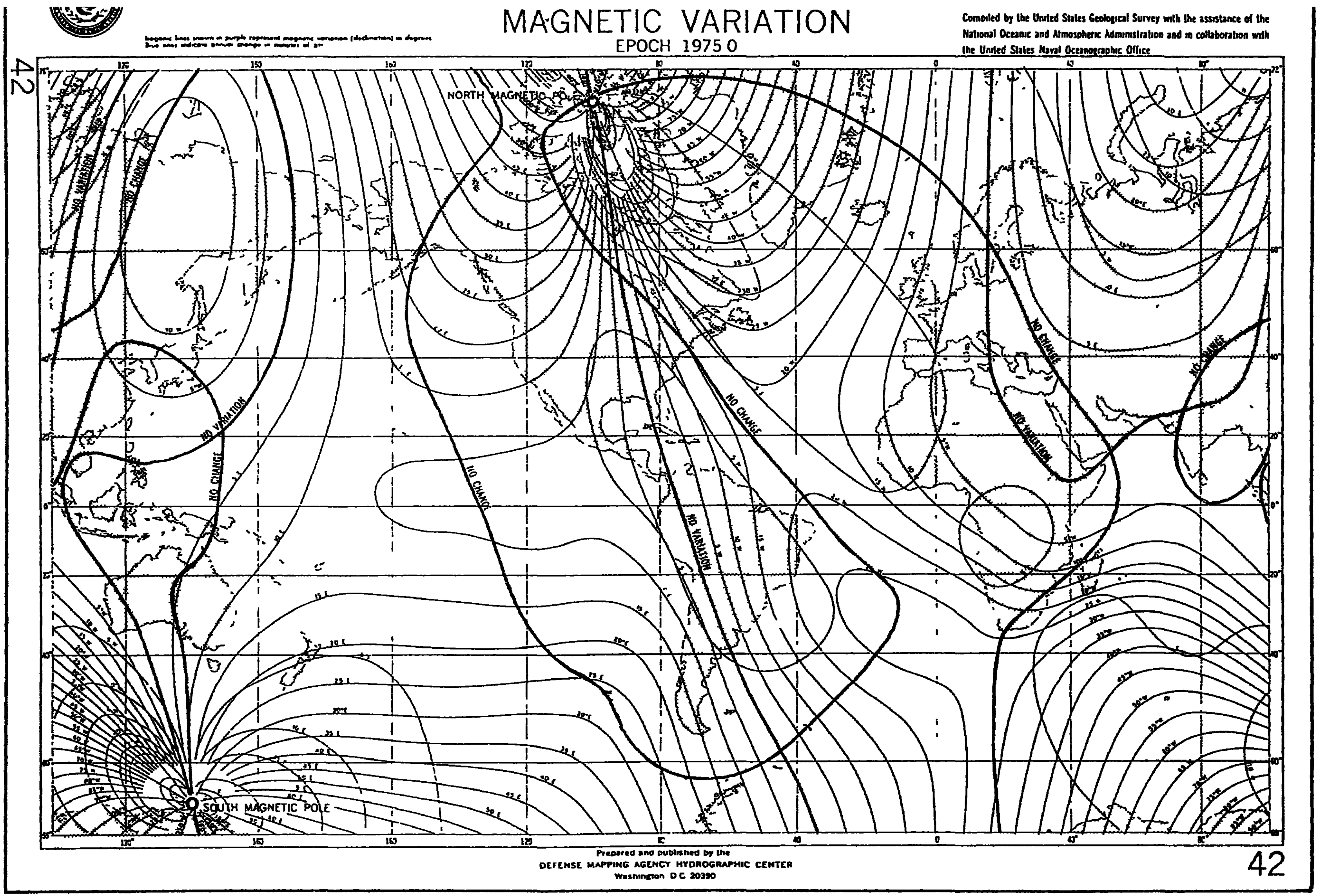


Figure 1-8.—Magnetic variation chart of the world, chart 42.

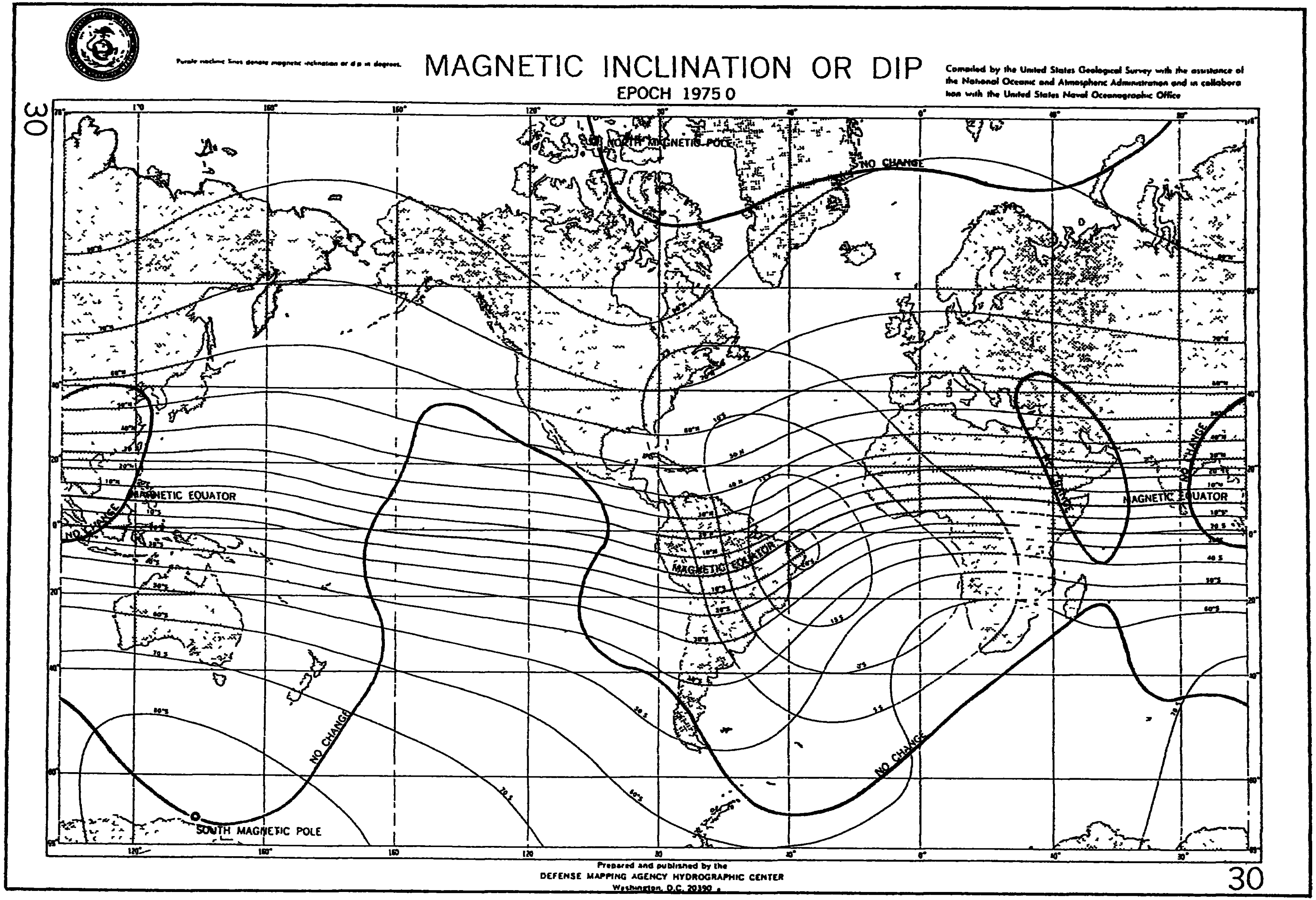


Figure 1-9.—The magnetic inclination or dip chart, chart 30.

CURVE OF DEVIATIONS

(Constructed upon the Napier Diagram)

)f the STANDARD Compass No 12826, on board the

USS CHICKASAW (DDG-19)

(Name and number)

Date of observations 25 OCT 19 90 Lat 29° 18'S Long. 107° 32' W

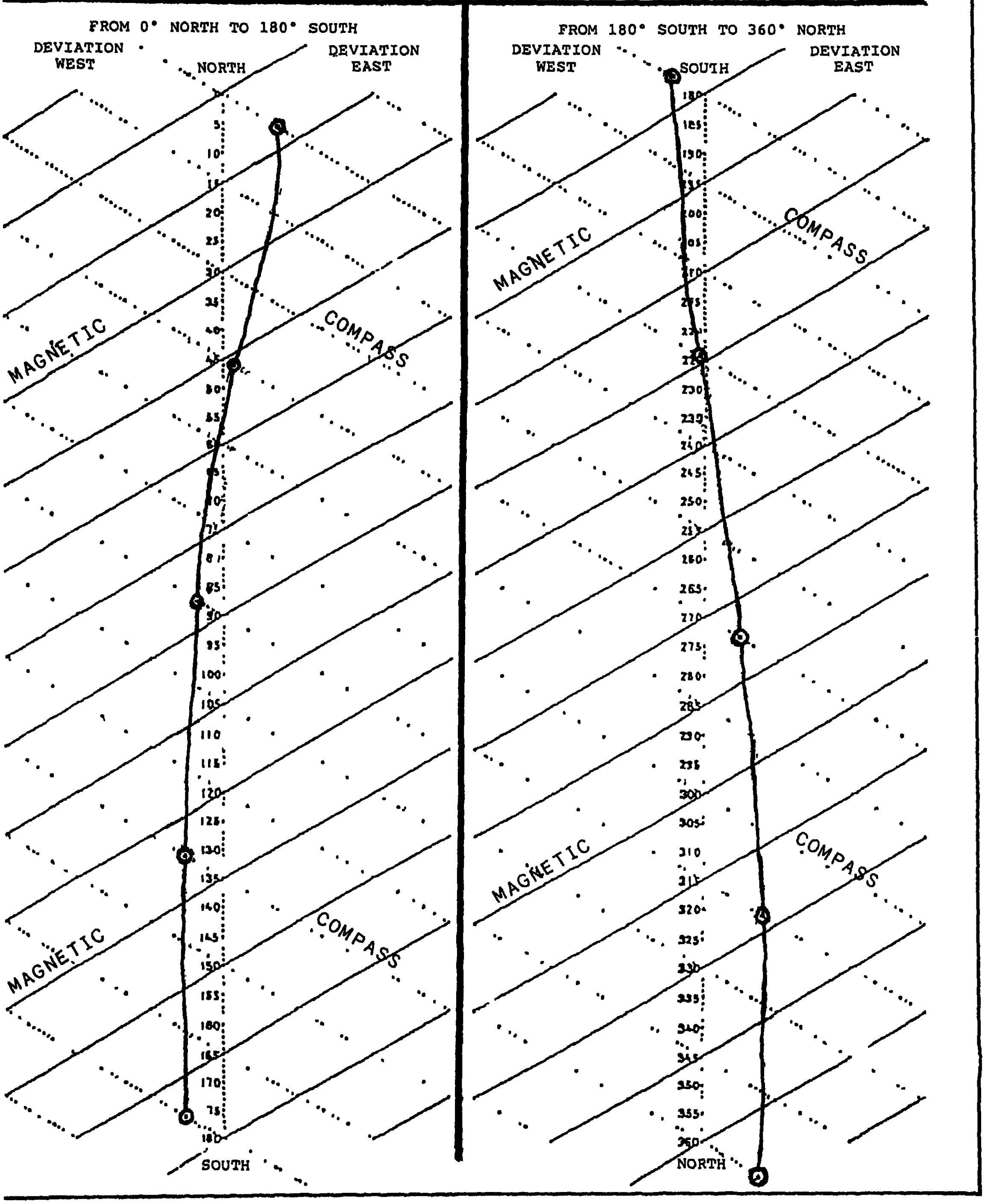


Figure 1-10.—Napier diagram.

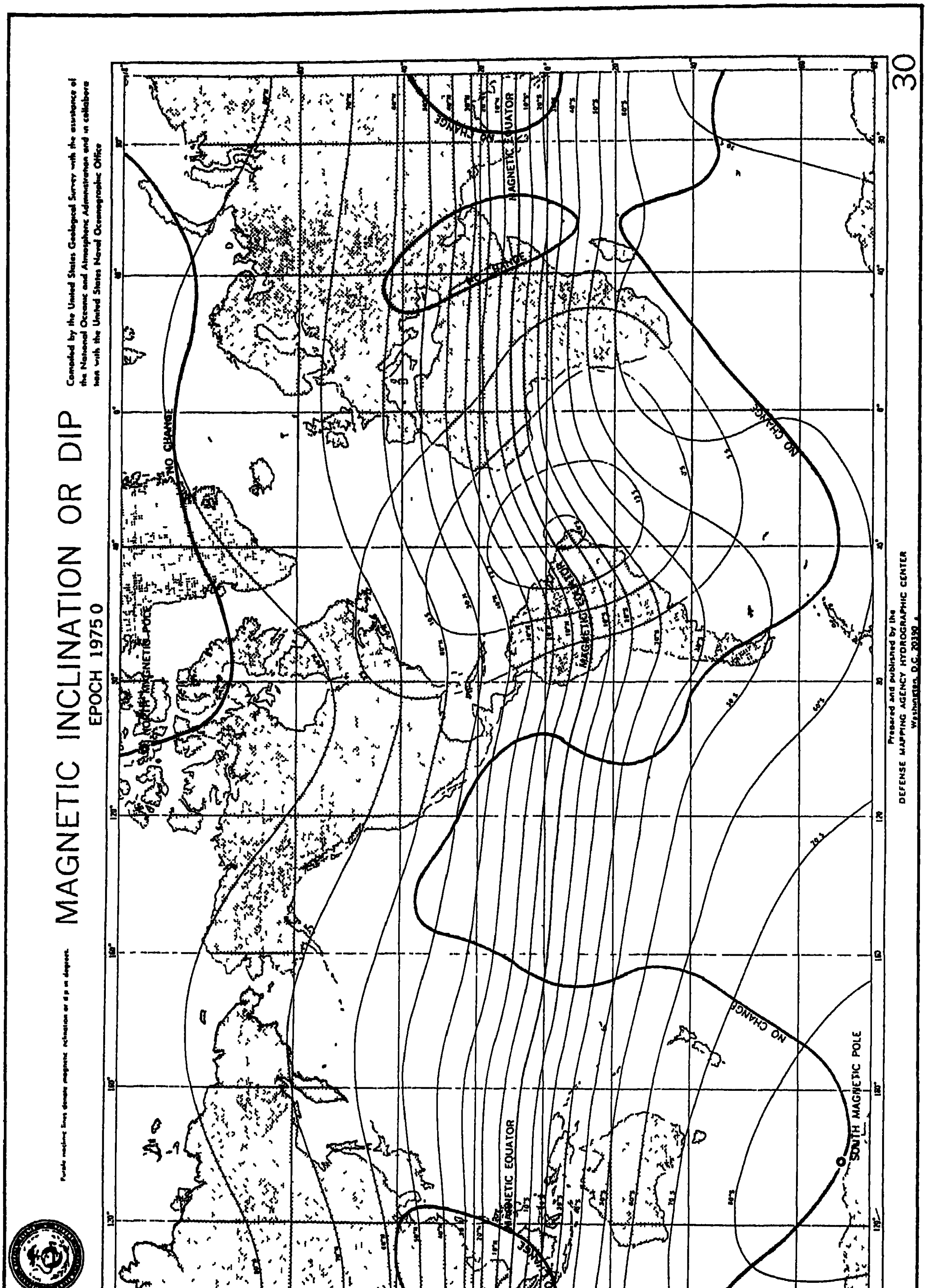


Figure 1-9.—The magnetic inclination or dip chart, chart 30.

CURVE OF DEVIATIONS

(Constructed upon the Napier Diagram.)

of the STANDARD Compass No 12826, on board the USS CHICKASAW (DDG-19)

(Name and number)

Date of observations 25 OCT 1990 Lat. 29° 18'S Long 107° 32'W

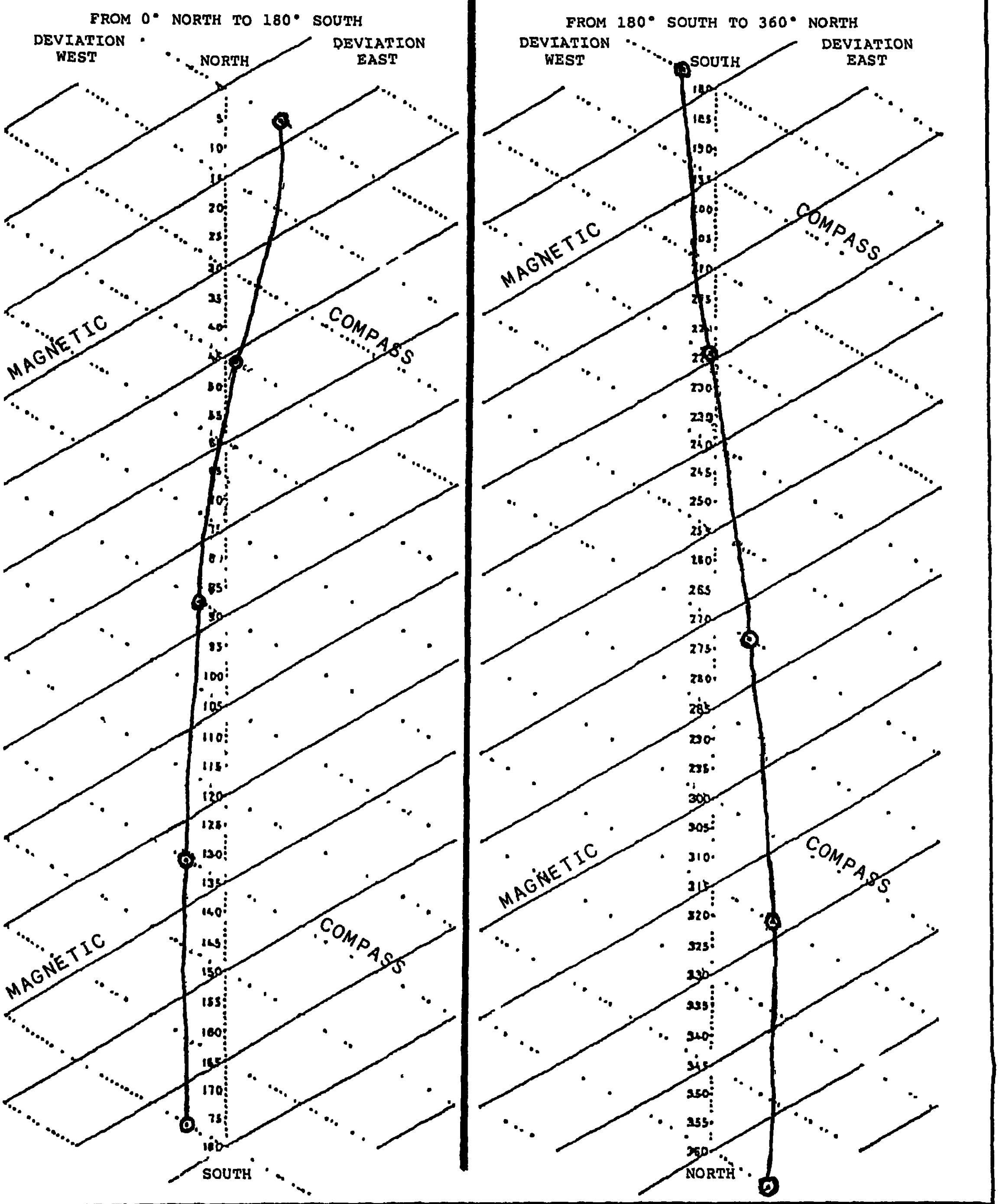


Figure 1-10.—Napier diagram.

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CHAPTER 2

VOYAGE PLANNING

Scheduled deployments, operations, and assignments can and will be, if circumstances warrant, extended, altered and/or changed. Whether these changes consist of long at-sea periods, extended time away from home port, or geographic reassignment, you as assistant navigator and/or senior Quartermaster must be prepared for these and other contingencies. Obviously, whatever the circumstance, at-sea operations can place severe restrictions and limitations upon your ability to procure, resupply, and replenish needed or expended materials and other resources.

This chapter briefly discusses some of the various elements and phases that comprise voyage planning. Voyage planning is a collective title given to preplanned evolutions and actions designed for scheduled events and possible alterations and/or changes.

At the conclusion of this chapter, you will be able to identify underway periods and commitments, collect and collate instructions and orders, plan and orchestrate your divisional preparations, and organize the voyage-planning process.

DEPLOYMENT CONSIDERATIONS

Deployment schedules are published and issued by fleet commanders. For example, CINCLANTFLT publishes a pre-deployment schedule for Atlantic units, and CINCPACFLT for Pacific units. Typically, these schedules are made available well in advance (annually, quarterly, and so on) and provide sufficient information to permit planning and organizing. Because ships movement information is restricted, a detailed discussion concerning deployment schedules will not be addressed.

The importance of knowing your intended schedule gives you time to procure supplies, gather materials, and make other necessary arrangements prior to getting underway.

UNDERWAY OPERATIONS

Various commands, ranging from the CNO through squadrons, issue long- and short-range operations schedules. These schedules can directly affect your ship for the year, quarter, or week. They affect the movements of your ship and all phases of your job.

Navy scheduling is not at all complex, but it is usually long range. Some ship types have their whole operation schedule laid out from commissioning to their first regular overhaul. Your command will devise its quarterly schedule from a sliding yearly schedule. You need as much lead time as possible on each operation so you can prepare for it. You do this by working through your ship's chain of command to procure and maintain a current ship's yearly and quarterly operation schedule.

OPERATION ORDERS

Operation orders (OPORD) are the primary means by which Navy commanders communicate their sailing and operating orders to the fleets, groups, squadrons, and ships.

OPORDs can be very lengthy documents. The extent of the operation, number of participants, and supporting requirements may dictate a vast number of operations into a single overall scenario. NATO exercises, usually conducted in European waters, include international participants, are logistically intensive, and utilize surface, air, and amphibious units.

Whether operational magnitude or complexity, OPORDs may be a single document or composed of additional follow-on directives. These follow-ons are called general operating (OPGEN) or operating tasks (OPTASK) messages. Messages of these types usually detail additional and/or amplifying information.

NAVIGATION INFORMATION

The OPORD obviously details your ship's movement, destination, and other operational data. Extracting the necessary information can be difficult. *Naval Operation Planning*, NWP 11, is the publication that governs OPORD composition and discusses dissemination. Procuring and reviewing NWP 11 simplifies your task.

Because OPORDs are maintained by your ship's Operations Officer and the OS gang in CIC, you must maintain a close working relationship, not only for advance word but for any changes or alterations that may occur.

OPERATIONAL REQUIREMENTS

Vessel type, class, and capabilities all figure into operational requirements. These same requirements dictate when and where your vessel operates. As ANAV, you must be aware of the operational capabilities of your command, and when and how you may be called upon to perform, which in turn effects ship's navigation.

RESEARCH PROCESS

Having procured and reviewed your operation schedule and determined your underway periods, you should be aware of the scope and purpose of operating plans. Understand, from a planning perspective, that operations can change and your ability to respond directly affects the command's performance.

In your role as ANAV, evaluating your vessel's involvement entails reviewing ship's standard operating procedures (SOP), navigation bills, and other applicable directives. Generally, this preplanning gives you the opportunity to prepare and organize, if necessary, prior to actual operations.

OPERATIONAL EVALUATION

ANAV evaluation includes not only determining involvement, but maintaining, updating, and re-evaluating changes that may occur. Duplication of process between yourself and the Operations Officer, as delineated by the SORM, should not occur. Your interest is the safe navigation during the performance of assigned duties and operations.

VOYAGE PLANNING

During your tenure as assistant navigator and/or senior Quartermaster, you probably will take part in extended cruises. These deployments differ from routine daily operations and short cruises mostly because you will not have ready access to supplies, replacement equipment, and external repair facilities. Therefore, planning and preparation should be very thorough.

PERSONNEL

Most deployments today are between 2 and 6 months long. Since these deployments are quite long, each member's projected rotation date (PRD) and expiration of active obligated service (EAOS) must be inspected and his or her contribution to the deployment evaluated in terms of training and experience.

Most deployments have personnel training requirements that you must address before getting underway, An example is the requirement to have one or more navigation school graduates on board, making him or her a "trained mandatory." Another is personnel whose EAOS or PRD occurs during the deployment and even more so if any of them are trained mandatories. If you have a member of your division in this situation, one of the following three events must occur:

1. The member must extend on board to complete the deployment if only the PRD is affected.
2. The member must reenlist or extend his or her EAOS to complete the deployment.
3. The command must transfer and replace the member before or during the deployment.

The problem presented by choice number 3 above is that the member most likely will be a QM2 with quite a bit of experience and training, and his or her replacement will most likely be a QMSA fresh out of QM A school or a seaman or seaman apprentice out of deck division or recruit training. These situations can be controlled with long-range planning and command coordination.

NAVIGATION EQUIPMENT

Your navigational equipment must be in its best operating condition. This equipment includes timepieces, depth-sounder, azimuth circles, binoculars, drafting machine, stadimeter, sextant, bearing circle, and telescopic alidades.

Actual repairs on that equipment are made (usually) at a repair activity or by qualified technicians aboard ship. For instance, chronometers should be turned in to supply and a replacement ordered if their overhaul due dates will approach during the cruise (understand that this process could possibly take 5 months and even longer); Sonar Technicians usually make necessary repairs to the depth-sounder, and azimuth circles and binoculars should be sent to a tender or repair ship for repairs. Simple adjustments to appropriate equipment, however, can and should be made by operating personnel. Some of the adjustments are discussed in the following paragraphs:

- Drafting machine—normally no repairs are made by operating personnel. At least two drafting machines/parallel motion protractors (PMPs) should be carried aboard, with one used as a backup. If one or more break down or need calibration, they should be turned in to the intermediate maintenance activity (IMA) under standard work-request procedures.

- Sextant—should be adjusted only when necessary, because frequent manipulation of the adjusting screws may cause excessive wear. Sextants should be checked before every cruise, but should be adjusted only when errors are excessive. When making adjustments, never tighten one adjusting screw without first loosening the other screw that bears on the same surface. Sextant adjustments that the user can make are listed here in the order in which they should be made.

1. Perpendicularity of the index mirror
2. Perpendicularity of the horizon glass
3. Parallelism of horizon glass and index mirror
4. Parallelism of the telescope

- Stadimeters—Since type II Fiske stadimeter is the one used most extensively by the Navy, only adjustments to that type are discussed in this text. Adjustments to the stadimeter are similar to adjustments to the sextant. An adjusting screw wrench to be used when making adjustments is included in the carrying case of each instrument.

1. Perpendicular adjustment of the horizon mirror
2. Perpendicular adjustment of the index mirror
3. Parallel adjustment of mirrors

A complete discussion on proper techniques and procedures can be found in *American Practical Navigator*, Pub. No. 9.

CONSUMABLES AND SUPPLIES

The type and quantity of consumable supplies you will need during deployment will be determined by your command/department instruction and deployment OPORD and instruction. These instructions include checkoff lists that will put you on track toward successful supply support for the deployment. On rare deployments and extended cruises when there is no specific governing instruction, the type and quantity of consumable supplies will be determined by three major factors: (1) length of cruise, (2) type of cruise (training or operational), and (3) where deployed (climate, time of year, and predicted weather).

The additional supplies needed for a deployment can present a particular problem when the subjects of "stowage at sea" and "item usage" are brought together. High-use items should be more accessible than low-use items. High-use items, such as pencils, should be stowed in or near the chart house or navigation center, as opposed to low-use items such as nautical slide rules, which need not be as accessible. However with your close supervision this problem will present little difficulty.

CHARTS AND PUBLICATIONS

The type and length of a deployment determine the type and number of charts and publications your ship needs After you acquire the scheduling information for your ship, you should address the following questions:

- Which charts and publications are needed?

- How many of each chart and publication are needed?

- What are the classifications of the needed charts and publications?

If you spend too much time waiting for an OPORD or MOVREP to help you answer these questions, you will leave little time to procure the additional charts and publications and make plans to stow them.

These additional charts and publications are just that, additional. Your ship's standard allowance must still be maintained

SAILINGS

The navigator (NAV) and assistant navigator (ANAV) must lay out the ship's complete intended track on the proper chart format. This task is undertaken after the planning stage is complete but several days or weeks before getting underway, depending on the length of cruise.

If your track will be less than 300 nautical miles, a small-scale Mercator chart will be adequate. However, for those tracks exceeding 300 nautical miles, you will probably use the gnomonic or Great Circle chart. There may be some cruises longer than 300 nautical miles where a Mercator or other type of chart is more appropriate than the great-circle chart.

GREAT-CIRCLE SAILING

You will recall from chapter 6 of the *Quartermaster 3* TRAMAN that the shortest distance between two points is a straight line. A straight line is perfect for navigational track planning using a great-circle chart (gnomonic projection).

The Defense Mapping Agency (DMA) publishes a number of charts, at various scales, using the gnomonic projection and covering the usually navigated portions of Earth. These are listed in the DMA *Catalog of Maps, Charts, and Related Products*, part 2, volume X. The point of tangency is chosen for each chart to give the least distortion for the area to be covered. Any great circle appears on this type of chart as a straight line. Because of this property, the chart is useful in great-circle sailing.

One of the first steps in plotting is to select a great-circle chart that has a point of tangency nearest your ship's predicted track.

Draw a straight line on the chart connecting the point of departure and the destination. See figure 2-1. Then inspect the great-circle track to see that it passes clear of all dangers to navigation. If this requirement is met, transfer the track to

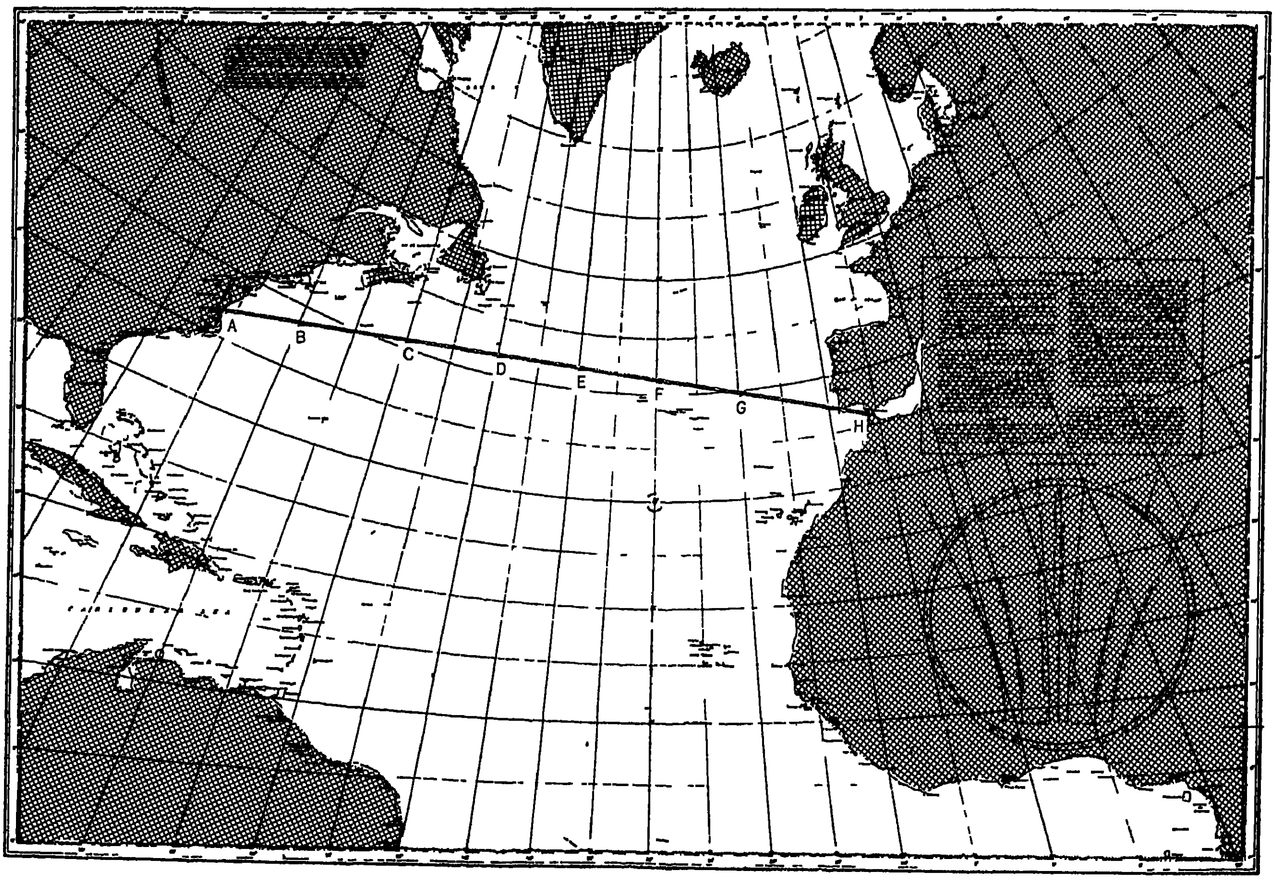

Figure 2-1.—Great-circle route, Norfolk to Gibraltar.

a small-scale Mercator chart that has all the occupied OPAREAs, sea lanes, severe-weather areas, and high-latitude limits laid out on it.

To transfer the track, first select convenient points along the great-circle track you drew on the great-circle chart. These points should be about 300 nautical miles apart. Next, transfer these points to the small-scale Mercator chart by replotting them at their correct latitude and longitude. Label each consecutive point with letters, always starting with an *A*, which normally corresponds to the first point outside the departure port or local OPAREA. The last point will be the position at which you enter the local OPAREA or your destination or just outside the destination port. Next, draw rhumb lines connecting these points. At this stage, the track appears as shown in figure 2-2.

Note that the rhumb line segments determined in the manner just described are chords of the great circle, as plotted on the Mercator chart. You can determine courses and distances of tangents to the great circle directly from the great circle charts. However, this method is somewhat involved and can best be understood by studying the explanation given on some gnomonic charts.

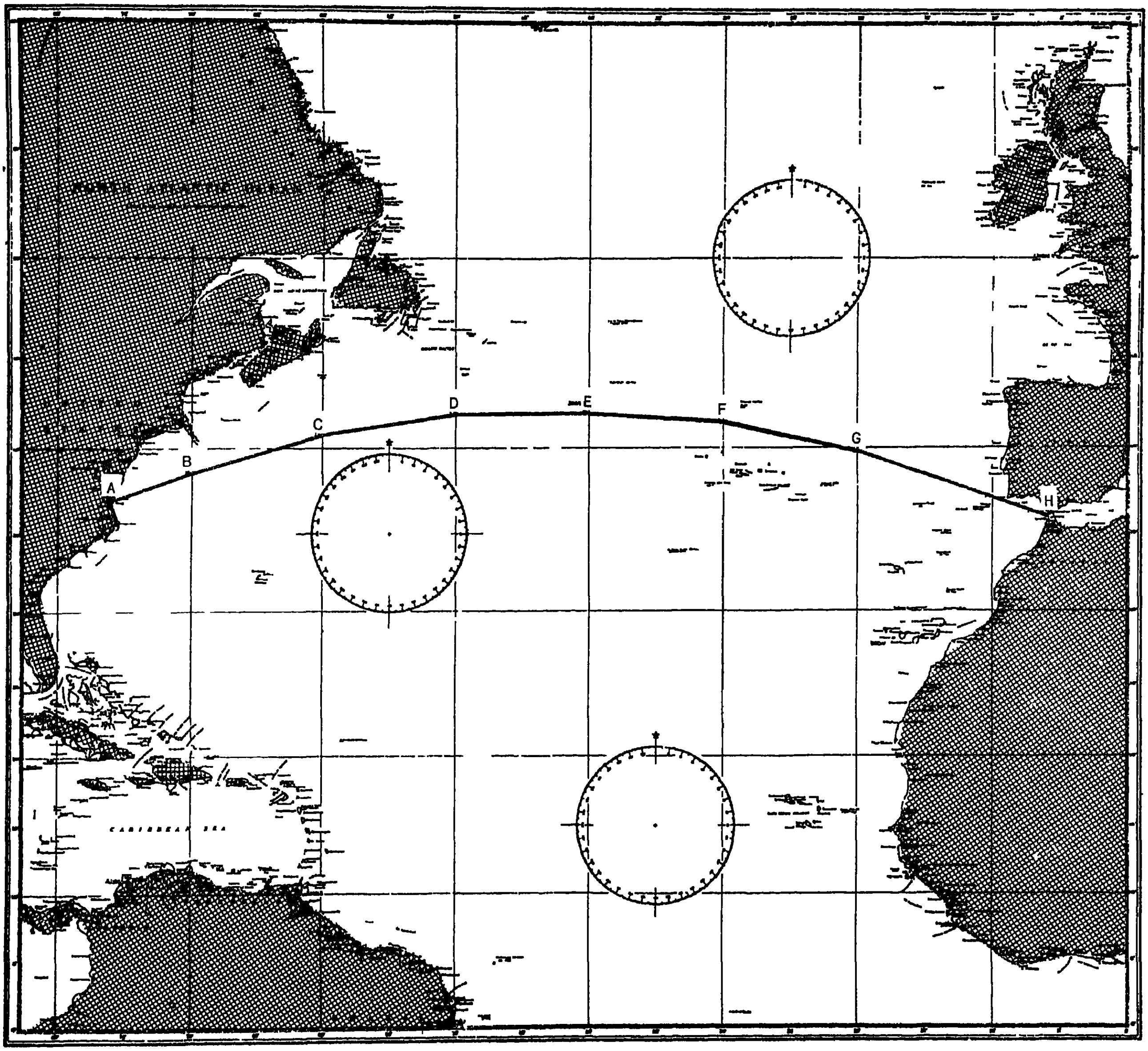

Figure 2-2.—Rhumb line approximation to the great-circle track.

The chord method is easier and is commonly used in practice.

The small-scale chart shown in figure 2-2 makes its use for actual navigation impractical. Therefore, you will need to lay out the points along the track and the rhumb lines connecting them on a larger scale "working" charts and/or plotting sheets. Each of these sheets displays approximately one rhumb line segment of your ship's track. This procedure is suitable for accurate and safe open-ocean navigation.

It should be mentioned here that it is also possible to determine a series of rhumb lines approximating a great-circle track by use of a modern electronic calculator or a ship's computer to solve a computational algorithm developed for this purpose. More sophisticated calculators, and calculators designed especially for marine navigation, come equipped with this algorithm "built in" to their navigation program packages or internal memories. Other applications for the electronic calculator in marine navigation are discussed in appendix A of *Marine Navigation 2*, and in *The Calculator Afloat* (available from the Naval Institute Press).

You will find with experience that most great-circle tracks are modified to avoid potential problems created by the following factors:

- Severe weather
- Land mass
- High latitudes
- Ocean traffic
- Prevailing winds or currents

For whatever the reason the track is modified, the impact on distance will be less when plotted on a great-circle chart than when "plotted around" the obstacle on the Mercator chart.

The next phase in laying out the ship's intended track is to measure and total the distances along the rhumb-line segments of the track. This measurement will be the actual distance measured along the track from the start to finish. The overall speed of advance (SOA) can now be computed using the total distance and total time between departure and destination. The term *overall SOA* is used purposely because each track segment's (leg) SOA can be different because of operational demand, the need to avoid interference, or severe weather routing (fig. 2-3). Next, compute the SOA for each leg, measure leg course, and label appropriately.

The ship's intended track across the ocean or to a desired position is still not complete. The last step is the CO's signature of approval.

Your ship may submit a track request, MOVREP, optimum track ship routing (OTSR), which is discussed in chapter 5, or a SUBNOTE may be provided via an OPORD. In any case, the plotting of the ship's complete intended track on the most suitable chart should be presented to the commanding officer for approval at least 15 days before the departure date or as early in the predeployment phase as possible. This time frame will give you enough time to prepare the working charts, the actual charts used to navigate the ship. These should be ready for the commanding officer's signature of approval approximately 3 days before getting underway.

OTHER SAILINGS

Parallel, mid-latitude, and traverse sailings are methods little used by today's mariner. Where great-circle sailings give the most accurate results and are unlimited in application, these other methods have severe disadvantages, as follows:

- Complex mathematical solutions are required.
- Less precise results are obtained.
- The course traveled must be due east or west.
- Unusable beyond a few hundred miles traveled.

A more in depth discussion can be found in the American Practical Navigator, Pub. No 9.

NAVIGATION BRIEFING

Prior to any underway evolution, whether departure or arrival, navigation briefings must be held. Normally, the navigator makes a formal presentation to the commanding officer, executive officer, and the bridge control team, plus any others the CO desires to be in the briefing. Because of your assistance with the planning and preparation phases, you may be called upon to either assist or make the actual presentation. At the minimum, present the information to the QM gang, plus answer any questions or provide clarification as needed.

In order to provide commonality and make sure adequate coverage is provided, higher authority, namely Commander Naval Surface Forces Atlantic and Pacific, respectively, have published instructions titled Navigation Standards and Procedures, COMNAVSURFINST 3530.2.

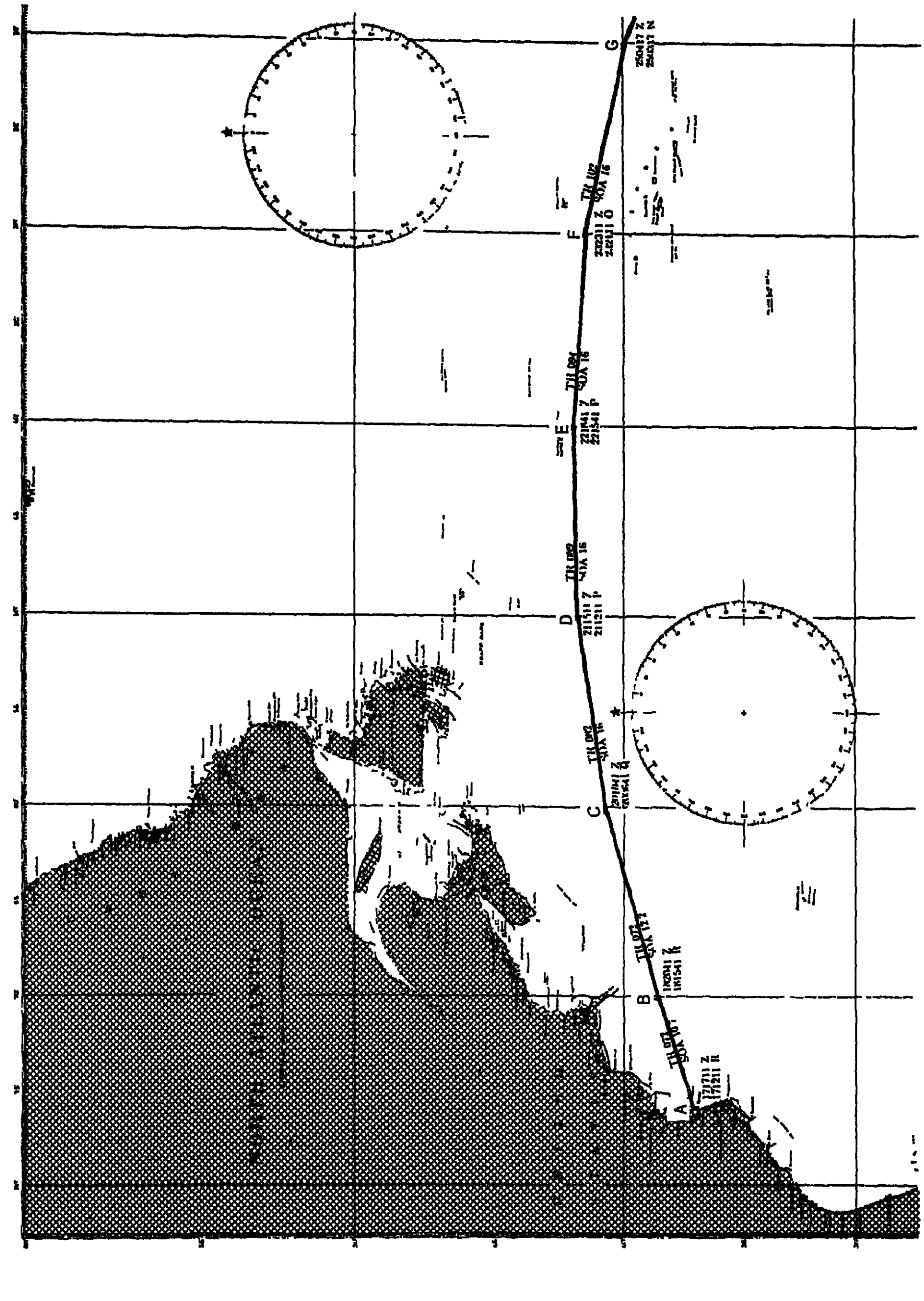

Figure 2-3.—Segment of a completed track.

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Parallel, mid-latitude, and traverse sailings are methods little used by today's mariner. Where great-circle sailings give the most accurate results and are unlimited in application, these other methods have severe disadvantages, as follows:

- Complex mathematical solutions are required.
- Less precise results are obtained.
- The course traveled must be due east or west.
- Unusable beyond a few hundred miles traveled.

A more in depth discussion can be found in the American Practical Navigator, Pub. No. 9.

NAVIGATION BRIEFING

Prior to any underway evolution, whether departure or arrival, navigation briefings must be held. Normally, the navigator makes a formal presentation to the commanding officer, executive officer, and the bridge control team, plus any others the CO desires to be in the briefing. Because of your assistance with the planning and preparation phases, you may be called upon to either assist or make the actual presentation. At the minimum, present the information to the QM gang, plus answer any questions or provide clarification as needed.

In order to provide commonality and make sure adequate coverage is provided, higher authority, namely Commander Naval Surface Forces Atlantic and Pacific, respectively, have published instructions titled Navigation Standards and Procedures, COMNAVSURFINST 3530.2.

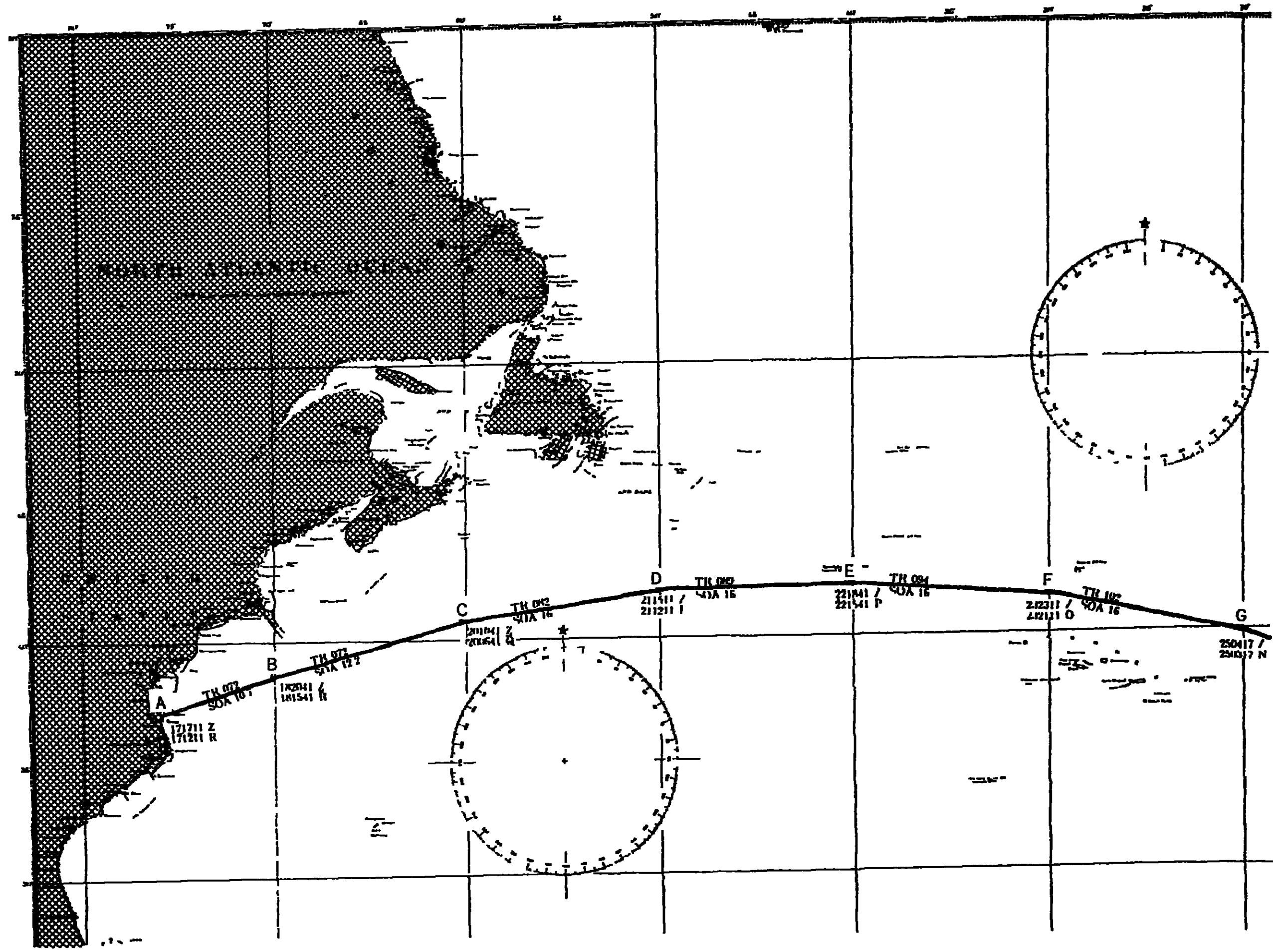


Figure 2-3.—Segment of a completed track.

Among the contents is an enclosure titled Standard Navigation Briefing. Figure 2-4 is an example from COMNAVSURFLANT.

SUMMARY

Voyage planning is a long-range process designed to foresee, plan, and organize for extended underway periods. Reviewing your ship's predeployment schedule periodically and being aware of changes when they occur allows you to adjust plans accordingly.

OPORDS are the primary means of communicating operating plans. Additional information may be forwarded via OPGENS and OPTASKS, dependent upon the magnitude and size of the operation and/or participants. As changes occur, re-evaluation of your ship's role and evolutions will allow you the ability to change as necessary.

Voyage planning also includes reviewing your personnel situation; is additional training required because of PRDs, EAOSs, and so forth? A thorough check of ship's navigational equipment must be completed and repairs performed. Sufficient supplies and consumables must be procured and properly stowed for handy use.

Standard chart allowances must be maintained. Deployments and operations may require procuring additional materials from DMA. Gnomonic charts, plotting sheets, and Mercator charts are used when calculating and plotting the preferred sailing method, great-circle sailing. Parallel, mid-latitude, and traverse sailings are normally not used by the U.S Navy, primarily because of severe restrictions and limitations.

The navigation brief must be a thorough and complete presentation. All concerned personnel should be indoctrinated by a briefing that is descriptive and informative.

REFERENCES

Maloney, Elbert S., *Dutton's Navigation & Piloting*, 14th ed., Naval Institute Press, Annapolis, Md., 1985.

Operational Reports, NWP 10-1-10, 1988.

U.S. Defense Mapping Agency Hydrography/Topographic Center, *Bowditch's American Practical Navigator*, Pub. No. 9, Vol. II, Washington, D.C., 1984.

NAVIGATION BRIEF

1. Assignment of Navigation Team statio
   a. Station assignments by name
   b. Personnel qualifications at each stat verified
   c. Review of duties
2. Review chart tracks
   a. Bridge/CIC charts and tracks compa
   b. Hazards to navigation marked
      (1) Danger bearings/ranges
      (2) Danger soundings
      (3) Navigation warnings
   c. Anticipated NAVAIDS
      (1) Nomenclature to be used
      (2) Planned NAVAID sequence
      (3) Expected sightings of lights
      (4) Buoyage system in effect
   d. Information
      (1) Maximum allowable deviati from track
      (2) Maximum safe speed
      (3) Planned fix interval
      (4) Anticipated traffic
      (5) Port requirements/regulations
      (6) Areas where ship can divert to anchor in emergencies
      (7) Suitability of RADNAV during l of visual NAVAIDs
      (8) Mooring/anchoring arrangemen
3. Review shipboard emergency procedur
   a. Communications
   b. Engineering control
   c. Anchoring procedures
   d. Fire/flooding response
   e. Concurrent flight/small boat operati
   f. Emergency shiphandling procedures
   g. Loss of steering drill
4. Navigation equipment status
5. Demarcation Lines
   a. Local/International Rules of the Rc (where applicable)
   b. Bridge-to-bridge RT requirements ε logs
6. Pilot and tug requirements
7. Environmental conditions
   a. Tides
   b. Currents
   c. Weather predictions

Figure 2-4.—Contents of a navigation brief.

CHAPTER 3

ASSISTING THE NAVIGATOR

As a senior Quartermaster, you will work more closely with the navigator than you did as a QM2. On smaller ships such as submarines and destroyers, you may qualify as the assistant navigator (ANAV). In that role, you may direct the operation of the navigation department when the navigator (NAV) is absent.

Whether you work as the ANAV on a smaller ship or as one of the senior Quartermasters on a large ship, you will need to know the duties of the navigator and your responsibilities in the navigation department.

When you finish this chapter, you should have basic knowledge of the following abilities: identify the duties of the NAV, ANAV, and Quartermaster (QM) division leading petty officer (LPO); describe their daily routines at sea; compile data and prepare navigation reports; and supervise and train personnel in navigation and watchstanding, and in the use and care of navigation publications and other at-sea and in-port procedures.

DUTIES OF THE NAVIGATOR

The head of the navigation department on a ship is called the ship's navigator. This person is normally senior to all watch and division officers aboard. On large combatant ships, the Chief of Naval Personnel assigns an officer as navigator. On other ships, the commanding officer may assign any qualified officer to the job.

The navigator is responsible, under the commanding officer, for the safe navigation and piloting of the ship. The navigator receives all navigation orders from the commanding officer and reports directly to the commanding officer concerning navigation

NAVY REGULATIONS

The following specific duties of the navigator are excerpts from *Navy Regulations*.

1. Advise the commanding officer and officer of the deck as to the ship's movements, and, if the ship is running into danger, a safe course to be steered. To that end the navigator will do the following:

a. Maintain an accurate plot of the ship's position by celestial, visual, electronic, or other appropriate means.

b. Prior to entering pilot waters, study all available sources of information concerning the navigation of the ship therein.

c. Give careful consideration to the course of the ship and depth of the water when approaching land or shoals.

d. Maintain record books of all observations and computations made in navigating the ship, with results and dates involved. Such books become a part of the official ship's records.

e. Report in writing to the commanding officer, when underway, the ship's position at 0800, 1200, and 2000 each day and at other times required by the commanding officer.

f. Procure and maintain all charts, *Sailing Directions, Light Lists*, and other publications and devices for navigation that may be required. Maintain records of corrections affecting such charts and publications. Correct navigational charts and publications as directed by the commanding officer and, in any event, prior to use for navigational purposes. Corrections will be made following such reliable information as may be supplied to the ship or as the Navigator is able to obtain.

2. Coordinate the operation, care, and maintenance of the ship's navigational equipment. To this end he or she will do the following:

a. When the ship is underway and weather permits, determine daily the error of the master gyrocompass and standard magnetic compasses and report the result to the commanding officer in writing; cause frequent comparisons of the gyrocompass and standard magnetic compasses to be made and recorded; adjust and compensate the magnetic compasses when necessary, subject to the approval of the commanding officer;

prepare tables of deviations and post correct copies at the appropriate compass stations.

b. Ensure that the chronometers are wound daily, that comparisons are made to determine their rates and errors, and that the ship's clocks are set to the local standard zone time or according to the orders of the senior officer present.

c. Ensure that assigned electronic navigational equipment is kept adjusted, and, if appropriate, that calibration curves or tables are maintained and checked at prescribed intervals.

3. Advise the engineering officer and the commanding officer of deficiencies in the steering system and monitor the progress of corrective actions.

4. Inspect daily, more often when necessary, the deck log and take any corrective action as may be necessary and within his or her authority to ensure it is properly kept.

5. Prepare reports and records required in connection with navigational duties, including those pertaining to the compasses, hydrography, oceanography, and meteorology.

6. Conduct navigation training of personnel such as junior officers, boat coxswains, and boat officers; train quarterdeck personnel in procedures for honors and ceremonies and all junior officers in Navy etiquette.

7. Normally, be assigned to officer of the deck for honors and ceremonies and other special occasions.

8. Relieve the officer of the deck as authorized or directed by the commanding officer (in writing).

DUTIES WHEN PILOT IS ON BOARD: The duties prescribed for the navigator in these regulations will be performed by him or her whether or not a pilot is on board.

ORGANIZATION RELATIONSHIPS: The navigator reports to the commanding officer concerning navigation and to the executive officer for the routine administration of the navigation department.

A DAY'S WORK AT SEA

To assist the navigator effectively or to act as navigator of a small vessel yourself, you must know every phase of a navigator's typical day at sea. The day's work may be long and hard. It usually begins before sunrise and ends long past sunset. The navigator whose work is well organized follows a set routine to complete the day's work with maximum effectiveness and minimum confusion.

Modern shipboard navigation is done primarily with electronic equipment such as Loran-C, NAVSAT, Omega, and Sins. These systems are accurate, fast, and convenient to use. With them, electronic fixes are available routinely and continuously day and night. They need little planning other than that discussed in the training manual *Quartermaster 3*, NAVEDTRA 10157. Therefore, the following discussion of a navigator's duties focuses on situations where electronic and visual navigational aids (NAV-AIDS) are unavailable or in doubt for extended periods of time. Some examples are fixes taken on morning stars, sunlines, azimuths, and evening stars.

Morning Stars

To prepare for a morning star sighting, the Quartermaster on the evening watch computes the time of sunrise and twilight for the following day and informs the navigator. The navigator arranges for a morning call early enough to arrive on the bridge well in advance of the time to shoot morning stars.

The morning stars are taken as early as the condition of twilight permits, to ensure that enough observations can be made while the stars are visible. Observations of at least three stars or planets should be made, and more if possible.

Determination of ship's position is based on the results of star sights. This position is compared with the ship's dead reckoning (DR) position, which has been carried forward from the last fix. From this comparison, set and drift are determined, and a new DR track is laid out.

Sunlines

Most navigators try to get at least two sunlines each morning and two each afternoon. When possible, one morning sunline should be taken when the sun's azimuth is 090°, and an afternoon sunline when the sun bears 270°. For this purpose the sun's altitude should not be less than 15°. A line of position from a sun shot taken at either of these times results in the ship's longitude.

When the sun is observed at local apparent noon (LAN), as explained in *QM2*, the morning sunline is advanced (by the usual DR methods) the distance traveled by the ship in the interim. If LAN occurs after 1200 local time, the morning

sunline may be advanced along the DR track to 1200, and the LAN sunline retired to 1200. Usually the morning sunline and the LAN line intersect and form a fix.

Ordinarily, the afternoon sunline is not used to determine a fix unless no evening stars or electronic fix can be obtained. This sunline serves principally as a check on the DR position. Depending on the ship's course, this sunline may reveal whether the ship is to the right or left of its proposed track or whether it is ahead or behind its DR position.

Azimuths

Navy Regulations requires the navigator to determine daily the gyrocompass error and to report the results to the commanding officer. Normally, the error is determined by taking a morning or afternoon azimuth of the sun. Azimuths may be taken at any time provided the sun is visible and its altitude not too high; the best time, however, is early morning or late afternoon. When the sun is near the observer's meridian, its apparent motion (speed of change in bearing) is faster than at other times, and azimuths observed are likely to be less accurate. Errors determined by azimuths are applied to the gyrocompass readings when determining the course to be steered, taking bearings, or comparing the magnetic compass with gyrocompass readings.

Evening Stars

Times of sunset and evening twilight are usually computed at the time of the last afternoon sunline The approximate azimuths and altitudes of the stars expected to be observed during twilight are listed in the navigator's sight book. The NAV and ANAV make plans to arrive on the bridge before the appearance of the first stars. Evening stars are observed and plotted and the ship's position determined using much the same procedures as in taking morning sights.

Before securing for the night, the navigator leaves instructions with the QM of the watch (QMOW) and/or the officer of the deck (OOD) concerning aids to navigation expected to be sighted, changes of course or speed, and electronic fixes to be taken.

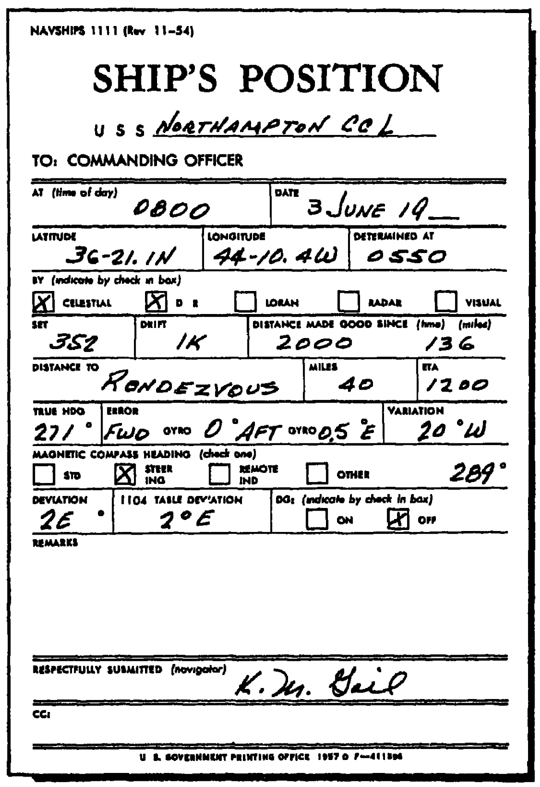
ADDITIONAL NAVIGATIONAL DUTIES UNDERWAY

During the course of a day, the navigator has many additional duties not mentioned above. Some duties are regularly scheduled, others occur as circumstances permit. Two examples of scheduled duties are ship's position reports and the Captain's night orders.

Ship's Position Reports

As prescribed by *Navy Regulations*, the navigator must report the ship's position to the commanding officer. These reports, called ship's position reports, are prepared and submitted three times daily: 0800, 1200 and 2000. Figure 3-1 is an example of a ship's position report. The report is formatted to provide the commanding officer with current ship's position, how it was determined, distance traveled and distance to a predetermined destination, plus the latest information concerning ship's gyrocompass and magnetic compass.

The completed report is submitted to the commanding officer prior to the appointed hour, usually about 15 minutes. For example, at approximately 0730, the navigator gathers the necessary information for filling out the 0800 position report. At this time the navigator corrects



NAVSHIPS 1111 (Rev 11-54)

SHIP'S POSITION

U S S NORTHAMPTON CC L

TO: COMMANDING OFFICER

AT (time of day) 0800 | DATE 3 JUNE 19__

LATITUDE 36-21.1N | LONGITUDE 44-10.4W | DETERMINED AT 0550

BY (indicate by check in box) [X] CELESTIAL [X] D R [ ] LORAN [ ] RADAR [ ] VISUAL

SET 352 | DRIFT 1K | DISTANCE MADE GOOD SINCE (time) 2000 (miles) 136

DISTANCE TO RONDEZVOUS | MILES 40 | ETA 1200

TRUE HDG 271° | ERROR FWD GYRO 0° AFT GYRO 0.5° E | VARIATION 20° W

MAGNETIC COMPASS HEADING (check one) [ ] STD [X] STEERING [ ] REMOTE IND [ ] OTHER 289°

DEVIATION 2E° | 1104 TABLE DEVIATION 2° E | DG: (indicate by check in box) [ ] ON [X] OFF

REMARKS

RESPECTFULLY SUBMITTED (navigator) K. M. Gail

CC:

U. S. GOVERNMENT PRINTING OFFICE 1957 O F—411596

Figure 3-1.—Ship's position report.

the DR track for course and speed changes that may have taken place since the morning star position was determined. Based on this DR position, the navigator makes out the position report and submits it in time to have it reach the commanding officer before 0800. Likewise, if LAN occurs before noon local time, the 1200 position report is made out using the information obtained in the LAN fix. When LAN does not occur until some time after noon, the 1200 position report must be made by using the information obtained from the morning sunline, DR position, electronic navigational aids, or any combination of these methods. The 2000 report is handled in the same manner. Evening stars may occur before or after 2000; but whichever the case, the commanding officer is informed of the latest information.

Commanding Officer's Night Order Book

The navigator is also responsible for the preparation of the CO's night order book. Night orders are the captain's orders of how he or she wants the ship run when he or she is not on the bridge. The book is normally divided into two separate parts: standing orders and night orders.

Standing orders are the commanding officer's statement concerning his or her policies and directions under all circumstances. Night orders, written on a daily basis, are a summary of tactical, navigational, and readiness information for bridge watchstanders. Additional information and guidance are added by the captain and the navigator. Figure 3-2 is an example of the captain's night orders.

Prior to writing the night orders, the navigator reviews the ship's operational orders and the nightly schedule of events for anticipated evolutions or activities. Should any conflicts exist between the schedule of events and the standing orders, the navigator informs the commanding officer.

The navigator then writes the night orders for the commanding officer, providing ship's information and operational data, including anticipated evolutions and a schedule of events if needed. The commanding officer then adds his remarks and the night order book is placed on the bridge. Among the watchstander's required to read and initial are the OOD, JOOD, BMOW, and QMOW. This intialing ensures that the orders have been read and understood.

Other Underway Duties

The preceding material discusses a day's work at sea and two examples of reporting and watchstanding. These functions occur every day and are scheduled evolutions. Some examples of other duties required by the navigator are the following:

- Carries forward dead reckoning continuously from the last fix until another fix is obtained.

- Obtains fixes by electronic navigational aids at frequent intervals.

- Submits weather reports according to the ship's operational orders.

- Tests daily those instruments used in navigation, including depth-finding equipment.

- During manuvers on large ships, remains on the bridge, advises the conning officer regarding courses and speeds necessary to complete particular evolutions, and keeps the ship's navigational position available at all times.

- Before entering a harbor or anchorage, determines the state of the tide, state of the current, depth of the water, and type of bottom to be expected. Conducts navigational briefs and informs the OOD and QMOW of visual aids to navigation expected to be sighted, so that they may watch for and recognize them.

- When the ship enters a new time zone, directs that the ship's clocks be reset.

- Checks the deck log daily and signs it. Ensures that entries are complete and in proper form.

THE ASSISTANT NAVIGATOR

The navigator's day is a full and demanding one. Timely completion of many phases of this work depends on the help of an efficient ANAV. As leading Quartermaster, you will be expected to qualify as ANAV and provide this needed assistance. Obviously, all the individual duties and responsibilities cannot be listed, since every command is different and assignments and requirements will vary. The effective ANAV is qualified, knowledgeable, and well trained.

Captain's night orders

Ship . . . . Time Zone . Date . . . .
En route from . . . . . . to
Operating with . . . . Area . . . .
OTC . . . . Flagship . . . .

Standard Tactical Data

Formation . . . .
Base Course . . . . . °T . . . °pstgc Speed . . Kts . . . RPM
Axis . . . . °T Guide . . Bears . . . °T Dist . . . Yds

Screen Data

Type of screen . . . . Screen axis Circle . . . . . .
No. stations . . . . . No. ships . . . Unassigned sta.'s . . . . .
Screen cdr. . . . . Screen cdr. ship . . . .
Own ship station . . . . . . Patrolling station . Yes ( ) No ( )
Sta. ship . . . . Sta. ship . . . . Sta. ship . . . . . . Sta. ship
. . . .
. . . .
. . . .

Own Ship Data

Engines on the line . . . . . . Generators on the line . . . .
Plant . . . . Ship darkened Yes ( ) No ( )
Steering unit on line . . . .
. . . .
Equipment casualties . . . . . ETR . . . . . ETR . . . .
. . . .

Captain's night orders

Weather Data

Sunrise . . . . Sunset . . . . Moonrise . . . . Moonset . . . .
Navigation Remarks . . . .
. . . .
. . . .
. . . .
Weather remarks . . . .
. . . .
. . . .
. . . .

1. Carry out standing night orders. Check them over to refresh your memory.
2. Eternal vigilance is the price of safety.
3. Call me when in doubt and in any event at . . . .

. . . .

Signature (Commanding Officer) . . . .
Signature . . . . Signature . . . .
(Navigator) (Executive Officer)

Night intentions . . . .
. . . .
. . . .

Watch	OOD	JOOD	QMOW
20-24			
00-04			
04-08*			

Figure 3-2.—Captain's night orders.

NAVY POLICY

The *Standard Organization and Regulations of the U.S. Navy*, (SORM), OPNAVINST 3120.32B, is an instruction issued by the Office of the Chief of Naval Operations (OPNAV). The purpose of SORM is to provide regulations and guidance governing conduct of all members of the U.S. Navy. The basic intent is to supplement *U.S. Navy Regulations* and provide standardization throughout the Navy.

Because *Military Requirements for Chief Petty Officer*, NAVEDTRA 10047, details both contents and administrative requirements of the SORM and since the scope of the instruction is beyond this manual, only those items related to navigation will be mentioned. These include the following examples:

Navigator: Lists the general and specific duties, plus responsibilities

Navigation watches: Lists underway watches and watchstanders duties

QMOW: Describes in-port QMOW watchstanding

Navigation Bill: Describes duties and procedures for safely navigating a ship, including navigating in restricted waters in low visibility

Deck Log: Record keeping of evolutions and events affecting a command, both in port or at sea

Magnetic Compass Record: Details the manner, requirements, and responsibilities of record keeping and administrative review by both the navigator and commanding officer

Other topics listed are safe navigation, night order book, helmsman, lee helmsman, and after steering watchstanding, plus departmental and divisional organization and training.

OPNAV instructions, such as the SORM, are mandatory requirements. Your commanding officer will determine how compliance with the SORM is met. Individual command requirements are usually written as command or unit instructions and other forms of directives. As ANAV you must know what these requirements are, plus have divisional copies available for review and incorporated into normal administrative matters and regular divisional training.

COMMAND REQUIREMENTS

Fleet ANAV qualifications have been established by the Chief of Naval Education and Training (CNET) using the personnel qualification program (PQS). The PQS booklet *Ship Control and Navigation*, NAVEDTRA 43492-2B, contains the fundamentals, systems, and watchstations recognized by CNET as the minimum qualifications for ANAV aboard U.S. Navy ships; included are watchstanding, administration, weather reporting and observing, manuvering board, sight reduction, supervision, and training.

Your command may tailor a more demanding navigation program in conjunction with the PQS program, which may encompass command policies, directives, and organization, plus mission and function requirements, along with ship's operations and capabilities.

TRAINING AND READINESS

One of the primary criteria for evaluating leadership and professionalism is your division's readiness. Readiness is the ability to respond, to perform, and to successfully accomplish assignments and tasks. Training is the key.

DEPARTMENT ORGANIZATION

The size and complement of your ship determines department organization. The navigation department, one of the basic departments found aboard all ships of the U.S. Navy, may or may not be a separate division. The structure used on a particular class of ship is based upon the organization for battle.

Two documents devoted to organizing and assigning personnel on a ship that are common to all ships are the battle bill and the watch quarter and station bill.

The battle bill assigns personnel to stations according to the qualifications required of them in battle at general quarters. The minimum number of personnel needed to operate the ship's equipment determines the size of the crew under the allowance and complement system of the battle bill.

The battle bill not only assigns personnel with certain qualifications to specific jobs on a ship while at general quarters but also does this for all conditions of readiness. This complements the organization of watches for conditions of lesser readiness when all hands are not at a battle station.

The watch, quarter and station bill lists the duties of each individual in each emergency and watch station. Additionally, the bill lists individual duties and billet number within the ship's administrative and operational bills.

As a qualified ANAV, you are expected to have in-rate knowledge and expertise. Fundamental to readiness is exactness to administrative matters affecting your personnel.

TRAINING

One of your most important jobs is the training of your navigation department or division and navigation watch personnel. Lectures, self-study materials, drills, and walk-throughs are common approaches you may consider. This section discusses the three training situations that you should address on your training schedule: standard operations, special operations, and emergencies.

Standard Operations

Standard operations should make up approximately 70 percent of your quarterly training schedule. This will give consistency to your overall training program.

Classes and drills should be held as scheduled. Training in any phase of departmental responsibility will, of course, contribute to the overall efficiency of the department. Give particular emphasis to these points:

Maintaining the DR position of the ship

Solving basic manuvering board problems

Rendering honors and ceremonies

Complying with Rules of the Road

Keeping time during observations and taking care of time pieces

Observing weather and weather reports

Using electronic aids to navigation

Using and caring for charts, tables, publications, and classified matter

Winding and checking chronometers

Special Operations

Special operations are unique. They require extra training consideration, especially if your personnel lack experience.

The following partial listing of special operations will serve as a good starting point for training:

High-latitude and arctic operations

Bottom-contour navigation

ASW operations

Anchoring and piloting

Naval gunfire support

Mine laying

Underway replenishment

Amphibious landing

Emergency Situations

Unexpected occurrences that create hazards for your ship, a ship or aircraft nearby, or personnel are emergency situations. Some of the most common examples that require training are as follows:

SAR operations

Man overboard

Reduced visibility

Loss of gyrocompass

Piloting with extensive superstructure damage

Abandon ship

The extent and variety of your department and division training will be evaluated during training record reviews and/or inspections. Therefore, your administration of training records must be timely and comprehensive. However, your department/division's performance during evaluated exercises and, more importantly, during actual situations will show the effectiveness of your training program. You can learn more about schedules, records, and additional essential training information in *Military Requirements for Petty Officer First Class*, NAVEDTRA 10046.

RECORD KEEPING

One of the measures of training effectiveness is the manner and methods used by your personnel in record keeping. Accuracy, timeliness, maintenance, and disposition of records are measures of your personal supervision and management effectiveness.

The following is a partial listing of logs and records, with governing instruction, which your personnel may use on a daily basis at sea:

The Ship's Deck Log: (OPNAVINST 3100.7 series)

It is the official daily record of the ship.

The ship's deck log is unclassified except when required by security regulations; that is, wartime opertions, special operations.

The log describes every circumstance and occurrence of importance and interest that concern the crew, concern the operations and safety of the ship, or are of historical value.

The ship's deck log is a chronological record of events.

The navigator is responsible for seeing that the deck logs are properly maintained.

- The logs should be reviewed daily.
- The title page is signed monthly.
- The deck log is submitted to the CO monthly or at the change of command.
- The original is submitted to the CNO within 10 days of the 1st of the month. If at sea, it is submitted with in 10 days of arrival in port.
- Duplicate logs are kept for 6 months, after which they may be destroyed.

Navigator's Workbook (OPNAVINST 3530.3)

It is required by *U.S. Navy Regulations.*

It is a record of all computations requiring a strip form to obtain necessary information such as:

- Celestial computations
- LORAN
- OMEGA
- Tides/currents

Strip forms are provided in the back of each book.

Modification of computation strips to suit personal preference is acceptable. Note: Any modified strip form is to become an official part of the record.

The navigator is responsible for proper maintenance and must sign at the bottom of each page.

This book is retained on board for 3 years from the last entry.

U.S. Navy Standard Bearing Book (OPNAV-INST 3530.3)

This book is required by *U.S. Navy Regulations.*

It is used to record bearings, ranges, soundings, gyro error, chart numbers, date, time and amplifying remarks.

It is maintained to allow ship's piloting to be reconstructed.

An index of navigation aids used during piloting must be compiled, ensuring identification and location.

Errors are corrected by a single line through the error and initialed in the margin.

Each page is filled out until completed; lines are not skipped.

The bearing recorder signs his/her name immediately below the last entry upon relief or when the book is secured.

The bearing book is retained on board for 3 years after the last entry.

Radio Telephone Log (NTP 4(C), FLEET COMMUNICATIONS)

Voice logs are maintained on all telephone nets or circuits unless otherwise directed.

This log is a complete and continuous record of all transmitted or received voice traffic.

It reflects the quality of circuit, including operation conditions on that radio day.

The log should also include the following:

- Causes of delays on the circuit

- Frequency adjustments and changes

- Unusual occurrences, such as procedure and security violations

Visual Communications Log (NTP 4(C), FLEET COMMUNICATIONS)

The visual log is safeguarded and maintained by the signal watch supervisor when the visual watch is set or by the person qualified as the duty signalman when the visual watch is not set.

The guidelines for visual log entries are based upon common usage.

Local time is used to indicate watches.

The visual log should include the following entries:

- GMT date, followed by time zone

- All times except for local watch times are GMT

- Incoming/outgoing traffic

- Time of receipt

- Methods of transmission

As a minimum, the visual log must be retained for 6 months after the final entry.

MAINTENANCE/EQUIPAGE RECORDS

As leading petty officer/assistant navigator, you will be either fully or partially in charge of operation and maintenance of equipment used in the navigation department. This section of the chapter discusses various reports and records required in connection with that responsibility.

Custody of Equipage

The question of *custody* may prove baffling sometimes, but you must have a working knowledge of the various procedures concerned with custody if you are to effectively carry out your responsibilities.

As used in the Navy, *custody* relates to the physical possession of material and the assumption of responsibility for its use and care. Custody may be either actual or theoretical. For example, the department head having theoretical custody is liable for such supply functions as procurement (from or through the supply officer), issue, and accounting for the material within his/her department. The department having actual custody or physical possession is responsible for the care and stowage of the material. It is with this latter duty that you are mainly concerned.

Many ships have a custody card for every item of equipage shown in the allowance list for the navigation department, whether it actually is aboard or not.

The supply officer keeps a list of all equipage on board. When there is a change in department heads, the oncoming officer signs the custody cards and acknowledges receipt from the officer relieved. Division officers sign subcustody receipts for division equipage, and then usually hold petty officers accountable in the same manner for items they receive. The person signing a custody receipt for any article must realize that he/she is personally responsible for that article, regardless of who has possession of it.

Survey of Equipage

A *survey* is the determination of the disposition and expenditure from stock records and accounts of naval material that has deteriorated or has been lost, damaged, stolen, or otherwise rendered unavailable for its intended use, under circumstances requiring administrative examination into the causes of the loss.

Surveys may be either formal or informal. If disciplinary action is not called for in the circumstances—such as losses caused by weather, unavoidable breakage, wear, or other circumstances beyond control, or if the case presents no complications—it is customary for the commanding officer to order the department head to perform an informal survey. If it appears that loss was due to neglect, carelessness, or other culpability, however, the commanding officer orders a formal survey, conducted by one officer or by a three-member board headed by a commissioned officer. This officer or board attempts to fix responsibility for the loss. Disciplinary action, if warranted, may be taken against the responsible party or parties.

Despite the circumstances, the end result of a survey is to provide a method for removing unusable or lost material from records so that new

material, not in excess of allowance, may be ordered.

Shipboard Maintenance

Maintenance of ships is divided into two broad categories: preventive maintenance and corrective maintenance. Preventive maintenance consists of routine shipboard procedures designed to increase the effective life of equipment or to forewarn of impending troubles. Corrective maintenance includes procedures for analyzing and correcting material defects and troubles. The main objective of shipboard preventive maintenance is the prevention of breakdown, deterioration, and malfunction of equipment. If the objective is not reached, however, the alternate objective of repairing or replacing the failed equipment—corrective maintenance—must be accomplished.

As you know, a uniform system is now used for scheduling, recording, reporting, and managing ship maintenance. This system, called *the Navy Ship's Maintenance and Material Management (3-M) Systems*, is intended to upgrade the operational readiness of ships. Complete instructions on the 3-M system are contained in the *Maintenance and Material Management Manual* (OPNAVINST 4790.4).

Associated Equipment

Our discussion has dealt with maintenance and material management of equipage under your daily control, but consider the variety of equipment found in your work spaces that is controlled and maintained by other work centers. Many of the daily at—sea evolutions are dependent upon a variety of equipment; for example, the gyrocompass. You are not responsible for the maintenance or repair, yet gyrocompass repeaters, located throughout the pilothouse, are required to be checked daily for accuracy by the navigator. Other examples are the ship's helm and radar repeaters. Obviously, problems or difficulties are immediately reported to the appropriate work centers; your role is to ensure records and/or logs reflect incidents and discoveries (for example, gyro errors, steering problems). Documentation reveals trends, problem areas, and provides a continuing history of equipment status.

SUMMARY

The duties and responsibilities of the navigator are prescribed by *Navy Regulations*, with the SORM providing additional guidance. The day's work at sea, beginning early and ending late, is full and demanding. Celestial observations, reports, plus updating mission and operational requirements as changes occur are but a few of the navigator's daily duties.

Qualifying as assistant navigator begins with completion of Ship Control and Navigation PQS and any additional requirements imposed by your command. The role of the assistant navigator means that you, as the assistant navigator, must be the navigation specialist—highly professional, competent, and proficient in all areas. Possess an in-depth knowledge of all applicable instructions (for example, OPNAV Instructions), including requirements, as well as your command directives, and those policies that dictate or influence your role as assistant navigator.

Training and readiness are among your primary responsibilities. The ship's battle bill and the watch, quarter and station bill are excellent training tools. Personnel readiness is achieved by testing and evaluating your personnel. Increased readiness can be accomplished by developing short- and long-range training plans that complement the ship's master training plan. Your training should encompass not only the QM rating but also your unit's functional and operational capabilities.

Record keeping is required by *Navy Regulations*. The deck log, navigator's workbook, and others previously mentioned all constitute the official record of your command The legal implications mandate proper procedures, correct phraseology, and close personal attention.

Periodic review of logs and records are excellent sources of information concerning equipment status.

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CHAPTER 4

SHIP OPERATIONS

As a First Class Quartermaster, you are eligible for assignment to virtually any type of naval vessel. Aboard ship you could be assigned duties as the junior officer of the deck (JOOD), junior officer of the watch (JOOW), or petty officer-in-charge (POIC) when assigned to a tug, patrol craft, or other yard or district-type craft. The duties of a POIC are very similar to those of both the commanding officer and the officer of the deck.

Both the OOD/JOOD watches and PO in charge of a craft are positions of high responsibilities and authority. This chapter will acquaint you with some of the duties and responsibilities of these jobs.

Upon completion of this chapter, you should be able to identify the duties of the OOD, JOOD, and the JOOW underway. You should also be able to describe the fundamentals of maneuvering ships in formation, and the various forces affecting a ship, the various ship's characteristics, and the various phases of shiphandling required by special operations.

BRIDGE WATCH OFFICERS

Navy regulations require that certain commissioned officers be assigned specific watch stations, at sea and in port. The commanding officer has the flexibility of assigning additional watch officers as he or she desires or as operations warrant. The number and type of watch officer stations are basically standard throughout the U.S. Navy. This chapter discusses those watch officers that you will work with as quartermaster of the watch (QMOW) or assistant navigator (ANAV).

Figure 4-1 presents the diagram of a typical chain of command, at sea and in port, for bridge watch officers.

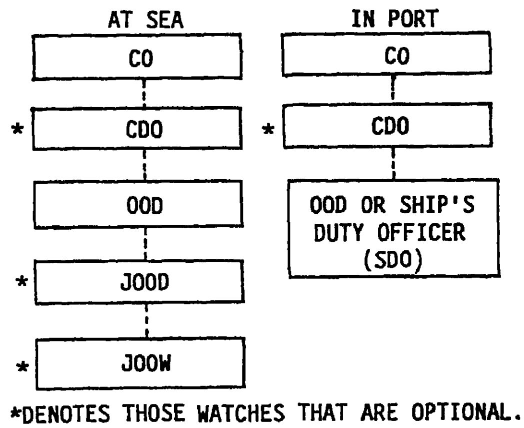

Figure 4-1.—Typical chain of command on the bridge.

OFFICER OF THE DECK

The officer of the deck (OOD) is the officer on watch designated by the commanding officer to be in charge of the ship. The OOD is responsible for the safe and proper operation of the ship and for the performance of all duties prescribed in *Navy Regulations* and the *Standard Organization and Regulations of the U.S. Navy*, OPNAVINST 3120.32, and the ship's commanding officer's standing orders and other applicable directives.

Some of the duties of the OOD are applicable only while the ship is underway; others, only in port. Some duties apply both underway and in port. The following text will discuss some of the duties of the OOD underway. For a more complete description of the OOD's duties, you should consult *Navy Regulations*, your ship's standing orders, and the *Watch Officers' Guide*.

The OOD must keep informed of current operating plans and orders, as well as of the intentions of the officer in tactical command (OTC) and the commanding officer.

When underway, the OOD usually may not change course or speed except as authorized by

the commanding officer. Some examples of specific occasions in which the OOD may change without prior permission of the commanding officer are as follows:

- when changing course is necessary to avoid collision or immediate danger

- when selecting a safe course to steer, based on the advice of the navigator

- when steaming in formation

In each of these events, however, prompt notification that a change has been made must be given to the commanding officer.

When at sea, the OOD must keep informed of the position of the ship and of all other particulars that may be of use in keeping the ship out of danger. The OOD must be thoroughly familiar with the laws to prevent collision and must comply strictly with those laws. The OOD must ensure that the ship is skillfully steered and, when in formation, that proper station is maintained.

When visibility is restricted, as by fog, rain, or falling snow, the OOD must have additional lookouts posted as required by *Navigation Rules*. The OOD must also ensure, by frequent checks and reports, that the proper navigation and running lights are bright lights as required by the rules.

The OOD is responsible for having frequent inspections made of watertight integrity, condition of armament, condition of ground tackle or mooring lines in use, good order and discipline of the crew. ship's boats, and any matter or circumstance that might affect the safety or operation of the ship. These inspections must be made and reported to the OOD either by a watch member established for that purpose or by a member of the OOD's watch section.

Other duties and responsibilities assigned to the OOD by *Navy Regulations* include taking necessary action to prevent accidents; controlling signals sent out from the ship; loading and unloading of the ship's boats; tending the side; rendering salutes, honors, and ceremonies; making prescribed reports to the commanding officer; and keeping the deck log.

JUNIOR OFFICER OF THE DECK

The junior officer of the deck (JOOD) is the principal assistant to the OOD. Routine matters that occur on watch may be handled by the JOOD. Frequently, the JOOD is in training to become a qualified OOD; accordingly, he or she may be assigned by the OOD to any duty that the OOD normally would perform. Any JOOD in anticipation of assuming those duties is well advised to learn as much as possible about the OOD's duties.

In the following topics, remember that the information concerning the JOOD applies equally to the JOOD whenever he or she has been assigned the particular duty under discussion.

JUNIOR OFFICER OF THE WATCH

Newly reporting junior officers (JOs) are frequently assigned the junior officer of the watch (JOOW) for training, when the JOOD watch bill is full. Senior enlisteds may be assigned the JOOW watch when additional supervisors are required during complex operations.

The JOOW, when assigned, is an officer on watch under instruction for qualification as officer of the deck. He or she reports to the OOD and performs tasks as assigned.

SHIPHANDLING

Shiphandling, like most phases of seamanship, can be learned thoroughly only through experience. Your duties as OOD/JOOD underway—but more especially as petty officer in charge of a craft of considerable size—probably will require an extensive amount of ship handling.

Yard craft usually are single-screw vessels, which are more difficult to maneuver than twin-screw ships of comparable size. Many of the advantages of twin-screw ships are not present in single-screw ships; for example, by backing down on one screw and going ahead on the other, you can maneuver a twin screw in a small space. For the foregoing reasons, the following discussion applies to single-screw ships. Remember, however, that the same operations and maneuvers can be performed with greater ease with a twin-screw ship.

SHIPHANDLING THEORY

Prerequisites to becoming a competent ship-handler include an understanding of the forces that influence ship movement and the ability to use them to advantage. The conning officer must know the maneuvering characteristics of his

ship, the effects of propellers and rudders, and the effects of various sea and wind conditions.

It is beyond the scope of this text to go into engineering technicalities, such as water flow patterns around the propellers and rudders, and associated mathematical formulas. Detailed information on these and other subjects of interest to the mariner may be found in such publications as Crenshaw's *Naval Shiphandling* and *Knight's Modern Seamanship.*

PROPELLERS

Generally speaking, a ship is moved by forces resulting from pressure differences. For all practical purposes, water is incompressible; therefore, when force is applied to a propeller, high- and low-pressure areas are created on opposite sides of the propeller blades. This force, called propeller thrust, is transmitted along the propeller shaft in the direction from the high-pressure area toward the low-pressure area. When the propeller is rotated clockwise, the low-pressure area is on the forward face of the blade, resulting in forward movement of the ship. (In the majority of single-screw ships, clockwise propeller rotation results in forward movement. In twin-screw ships, the starboard screw rotates clockwise and the port screw counterclockwise to obtain forward movement.)

Side Force

Next in importance to propeller thrust is side force, which tends to move the ship's stern sidewise in the direction of propeller rotation.

The upper blades exert a force opposite to that of the lower blades, but the lower blades are moving in water of greater pressure. Consequently, the force of the lower blades is greater. It is as though the lower blades were touching the bottom and pushing the stern to the side (figure 4-2). When going ahead the stern tends to starboard, and when backing, to port. Side force is greatest when the ship is dead in the water, or nearly so, decreasing rapidly as speed increases. It is greater when backing than when going ahead.

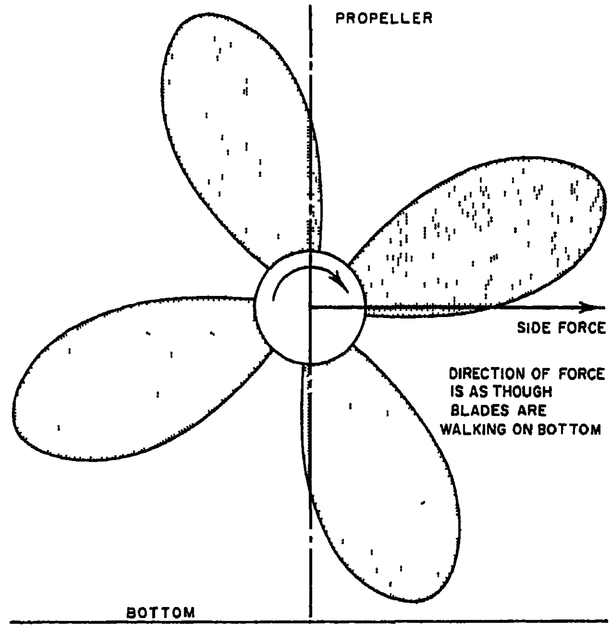

Figure 4-2.—Side force.

Frictional Wake Current

A vessel moving through the water will drag some of the water along because of friction between the skin of the ship and the water. This is called frictional wake current. Frictional wake current at the waterline is zero at the bow and increases to maximum at the stern. It is also maximum at the waterline and decreases with depth toward the keel. The degree of frictional wake increases proportionately to ship's speed and is greatest in shallow water. The underwater hulls of ships are streamlined to counteract the effect of skin friction.

Frictional wake current causes a loss in propeller efficiency because the propeller has to work in this wake. For example, if a ship is moving at 10 knots and has a following wake of 2 knots near the propeller, the propeller will be advancing at only 8 knots relative to the water. Frictional wake current also decreases the effect of side force.

Screw Current

Screw current, caused by the action of a rotating propeller, consists of two parts. The portion flowing into the propeller is the suction current, and the portion flowing away from the propeller is the discharge current. Suction current is a relatively minor force in shiphandling. Discharge current is a major force in two main respects: It is a strong force acting on the rudder with the screw going ahead; and it is a strong component of side force when the screw is backing, because of the discharge current acting against the ship's counter.

RUDDERS

Single-screw ships have a single rudder mounted directly behind the propeller. Twin-screw ships usually have a rudder mounted directly behind each propeller, but some ships have a single rudder mounted between and just abaft the propellers.

Basically, a rudder is used to attain or maintain a desired heading. The force necessary to accomplish this is created by dynamic pressure against the surface of the rudder. The magnitude of this force and the direction in which it is applied produces the rudder effect that controls stern movement and, through it, the ship's heading. Factors having a bearing on rudder effect include rudder size, rudder angle, rudder location, ship's speed, direction of propeller rotation, headway, sternway, suction current, discharge current, and side force. The diverse effects of all of these factors can be lumped together under a single term—resultant force—that indicates the direction and amount of thrust exerted on a ship's stern.

Resultant force can be shown by a vector diagram of side force, rudder force, and propeller thrust. A few examples of the nearly infinite number of combinations for a single-screw vessel are shown in figure 4-3. The vectors are not to scale, being merely representative of how resultant force is derived. The same principles apply to a twin-screw ship, the difference being that the additional screw increases the possible combinations—because of being able to oppose rotation, run one propeller and stop one, run both at different speeds in the same direction or in opposite directions, and so forth.

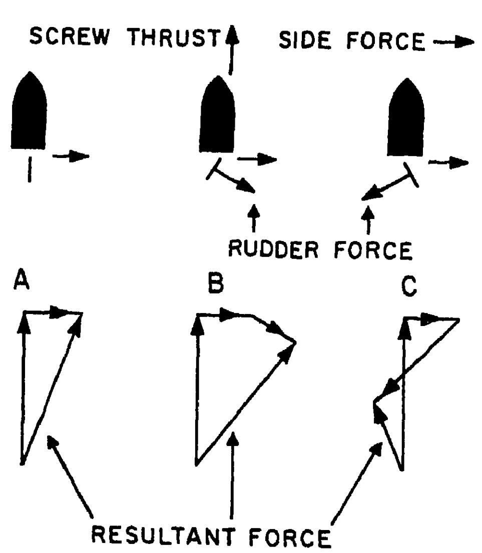

Figure 4-3.—Resultant forces, single-screw ship going ahead.

Figure 4-3 represents a ship at slow speed. In the situation in view A, it would be necessary to carry some amount of right rudder to overcome the side force and permit the ship to steer a straight course.

That a single-screw ship turns more readily to port than to starboard may be seen by comparing views B and C. In view B the side force and rudder force are additive, whereas in view C a considerable amount of rudder force is used to overcome the side force.

Pivot Point

A ship's pivot point is a point on the centerline about which the ship turns when the rudder is put over. The pivot point scribes the ship's turning circle.

A ship's pivot point is nearly always about one-third the ship's length abaft her bow when moving ahead, and at or near her stern when moving astern. The location of the pivot point will vary with ship's speed, an increase in speed shifting the pivot point in the direction of the ship's movement. In restricted waters the conning officer must always bear in mind the position of the pivot point before starting to make a turn. This is especially important when moving ahead to prevent the stern from swinging into an undesireable location.

Turning Circle

A ship's turning circle is the path followed by the ship's pivot point when making a 360° turn. Its diameter varies with rudder angle and speed. With constant rudder angle, an increase in speed results in an increased turning circle. Very low speed (those approaching bare steerageway) also increase the turning circle because of reduced rudder effect.

Knowledge of the turning characteristics of one's ship is essential to safe shiphandling, particularly when in restricted waters. Figure 4-4 illustrates a turning circle. While many of the terms have been addressed in the *Quartermaster 2*

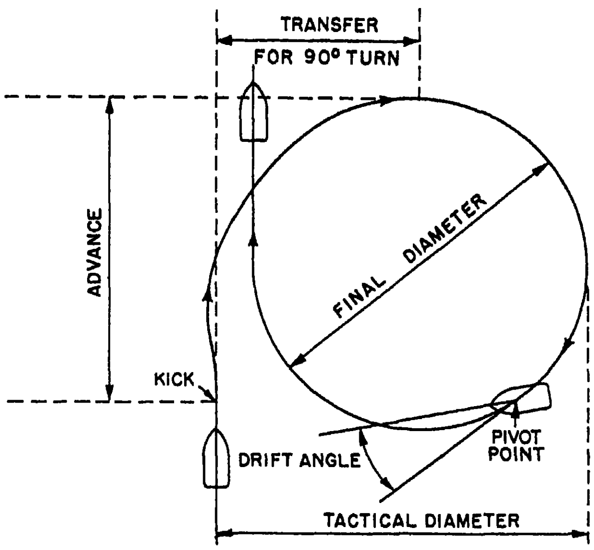

Figure 4-4.—Turning circle.

TRAMAN and will not be redefined, two additional terms need defining:

DRIFT ANGLE: Angle at any point on the turning circle between the intersection of the tangent at that point and the ship's keel line.

KICK: Swirl of water toward the inside of the turn when the rudder is put over. Also, the momentary movement of the ship's stern toward the side opposite the direction of the turn.

When the rudder is put over in making a turn, the stern is forced away from the direction of the turn. For several lengths the ship turns very slowly from her original course, because of momentum. She then commences to gain ground in the new direction, moving sidewise through the water to a considerable degree. This naturally results in loss of speed and is why, when a column turn is made, a vessel gains rapidly on the ship ahead while that ship is turning, but loses this distance during her own turn when the first ship completes her turn and steadies on the new course.

Each ship should have available on the bridge a folder of the ship's tactical characteristics; it should be carefully studied by all shiphandlers. Pertinent data should also be available at other stations concerned with ship maneuvers, such as the combat information center (CIC). These tables are drawn up with the ship making several turning runs at different speeds and using various rudder angles. Table 4-1 is a sample advance and transfer table for a ship making a turn at 15 knots, using standard rudder. Similar tables are compiled for other rudder angles at the same and different speeds. The time required to make the various turns may also be shown.

Table 4-1.—Sample Advance and Transfer Table

STANDARD TACTICAL DIAMETER
AT 15 KNOTS REQUIRING
STANDARD RUDDER

Angle of turn (degrees)	Advance (yards)	Transfer (yards)
15	185	40
30	275	85
45	345	115
60	390	190
75	445	270
90	500	375
105	450	445
120	405	520
135	360	590
150	315	655
165	265	725
180	205	800

Acceleration/Deceleration

At times, allowance must be made for the rate at which a ship increases and decreases speed. Another part of the tactical data folder, therefore, is the acceleration/deceleration table, of which a sample is given in table 4-2. Practical examples of its use follow.

Example 1: A ship is standing up a channel at 15 knots. The captain desires to maintain speed as long as possible, but must pass an anchored dredge at a maximum speed of 10 knots. Determine how far before reaching the dredge a speed reduction should be commenced.

From the deceleration table, it is determined that 1 minute is required to decelerate from 15 knots to 10 knots. Because the rate of deceleration is always constant between any two speeds, the average of these two speeds is the average speed of the ship during this time period. By computation, 15 knots plus 10 knots gives an average speed, during 1 minute of deceleration, of 12 1/2 knots. Determination of average speed

Table 4-2.—Sample Acceleration and Deceleration Table

Knots		Minutes		Rate
Change of speed		Time required for change	Total elapsed time	Knots per minute
From	To			
Acceleration				
0	10	3	3	3-1/3
10	15	2	5	2-1/2
15	20	2	7	2-1/2
20	25	5	12	1
25	30	10	22	1/2
Deceleration				
30	25	5	5	1
25	20	3	8	1-2/3
20	15	1	9	5
15	10	1	10	5
10	0	2	12	5

is the crux of this problem. To compute the distance the ship will travel in 1 minute at 12 1/2 knots, multiply 2,000 (yards) by 12.5 (knots) and divide by 60 (minutes); the result is approximately 417 (yards). Measure back 417 yards along the DR track from a point abeam the dredge. This latter point is where it is recommended that turns for 10 knots be rung up on the engines.

Example 2: A ship is proceeding through Ambrose channel at 10 knots. The navigator is informed that 25 knots is to be ordered when the ship clears the channel. Two computations are requested by the OOD:

1. How far along the DR track will the ship travel from the time 25 knots is rung up until she is making that speed?

2. How much time is required for the evolution?

Because the ship is proceeding at only 10 knots, a running tabulation of speeds and times must be considered. Going to the acceleration part of the table, compute the distance traveled in three steps: 10 to 15, 15 to 20, and 20 to 25.

Increasing speed from 10 knots to 15 knots requires 2 minutes at an average rate of speed of 12 1/2 knots (10 + 2 1/2). During this time the ship will travel 834 yards. From speed 15 knots to speed 20 knots takes 2 minutes at an average speed of 17 1/2 knots (15 + 2 1/2). During this time the ship will travel 1,167 yards (17.5 × 2,000 by 30). From speed 20 knots to speed 25 knots requires 5 minutes at an average speed of 22 1/2 knots (20 + 2 1/2). During this time the ship will travel 3,750 yards.

To answer the OOD's first question, adding the three distances gives 5,751 yards. The answer to his second question is the total time required (listed in the table), which is 9 minutes. After 25 knots is rung up, it will take 9 minutes to attain that speed.

PRINCIPLES OF SHIP HANDLING

To better understand the effect of various rudder and screw combinations upon a ship, assume these ideal ship handling conditions: no wind, no current, no tide, plenty of sea room, and no interference from other vessels. Further assume that the ship being conned is a yard craft (YO) with a single rudder and single right-handed screw (turns clockwise going ahead)

Going Ahead

In going ahead from a stopped position, the first noticeable effect is that the ship's stern swings to starboard because of side force. To counteract this swing, right rudder is applied, forcing the discharge current against the rudder surface. As the ship gathers headway from propeller thrust, the ship reaches a speed where the wake current overcomes side force to a great extent, and right rudder may be removed. Now the ship will continue straight and respond equally well to either left or right rudder. Rudder effect is obtained from the dynamic pressure of the discharge current and the pressure of the water through which the ship is moving.

With the ship going ahead at a good speed, suppose the conning officer wants to stop. The screw is backed. Propeller thrust is in direct opposition to the forward motion of the ship, causing her to start slowing. Side force and part of the discharge current tend to force the stern to port. This direction of movement can be compensated for by left rudder so long as the ship has sufficient forward motion to retain steering effect. As forward motion is reduced, however, steering effect is reduced to zero. Furthermore, side force and that part of the discharge current acting against the ship's counter cause the stern to swing to port. This trend can be compensated for partially by shifting to right rudder to take advantage of the force of the suction screw current acting against the rudder surface.

Backing Down

Backing down in a straight line with a single-screw ship is virtually impossible without alternating the direction of the screw and the position of the rudder.

In going astern from a stopped position, the stern swings to port because of side force and a portion of the discharge current. This force cannot be counteracted, even with full right rudder, because the suction current acting against the rudder surface is a relatively weak force. As the ship gathers sternway, the water through which the ship is moving acts against the rudder surface, augmenting suction current force. This force slows, but probably will not stop, the stern's continued swing to port. The best way to straighten out is to go ahead on the screw and, as discharge current builds up, shift rudder to left full.

Two forces now are working to stop port swing and bring the ship to her proper heading. These forces are side force and the discharge current acting against the rudder surface. When the heading of the ship is satisfactory, continue the backing procedure used initially.

Casting

Casting is the maneuver that often arises wherein ship's heading must be altered radically without allowing any appreciable change in her initial position. Casting is referred to also as *turning short, twisting ship, turning her on her pivot*, and by other terms. All these terms have the same meaning.

The rudder-screw combination used depends on the direction chosen to turn the ship; the shortest arc of turn is the simplest and quickest. The key to this maneuver is to apply all available forces to start the stern swinging before the ship gathers headway or sternway. If desired to pivot the ship to a heading on the port side, go ahead on the screw with full left rudder. Side force and discharge current acting against the rudder surface force the stern to swing rapidly to starboard before propeller thrust imparts forward motion to the ship. When the ship starts to gain headway, back the screw and shift the rudder. Side force from the backing screw slows the stern's swing, but this action is unavoidable. To remain in the ship's initial area, take way off the ship. When forward motion stops completely, go ahead on the screw and shift rudder to left full. Repeat these screw-rudder combinations until the ship is on the desired heading.

A pivot to starboard is accomplished by a different sequence of screw-rudder combinations. Start the maneuver by backing the screw with left full rudder. Side force and suction current against the rudder surface start the stern swinging rapidly to port. As the ship gathers sternway, shift rudder and go ahead on the screw. Repeat these screw-rudder combinations until the ship is on her desired heading. With a single-screw ship, it is easier and quicker to cast to starboard than to port.

Going Alongside

From the foregoing descriptions of handling a single-screw ship using various rudder-screw combinations, a conning officer should have a good idea of what to expect of a ship under ideal conditions. Now, let's consider some of the more common ship-handling situations encountered—going alongside, for example.

Port-side-to: It is always easier to bring a single-screw craft alongside port-side-to than starboard-side-to. The reason is that when the bow is eased in alongside the berth and the engine is backing down to kill headway, side force of the backing screw swings the stern in alongside the

berth. Figure 4-5 illustrates the effect of side force when backing.

Starboard-side-to: In a starboard-side-to landing, side force swings the stern away from the berth when backing down. Approach for a starboard-side-to landing, consequently, must be made at slow speed to avoid having to back hard to kill headway. Another disadvantage of a starboard-side-to landing engendered by a slow approach is that the less headway, the less will be the steering effect of the ship's rudder, thus making her harder to control.

Wind and Current

Often, advantage can be taken of what may appear at first to be adverse conditions of wind and current. It is in such a situation that the art of ship handling enters the picture. Plan a maneuver so that all known factors are taken into account. A time loss of a few minutes may be unimportant, but the Navy is highly critical of unnecessary damage to ships and installations resulting from lack of planning or poor judgment.

Current from ahead: If the ship has plenty of room and a fairly strong current from ahead, her bow can be eased alongside, and the forward bow spring line put out. The current will bring her in to the dock, as diagrammed in the first view of figure 4-6.

Current from astern: When current is from astern, putting out the after quarter spring line (second view in fig. 4-6) produces the same result as when current is from ahead. Going alongside with a current from astern is more difficult, however, because the following current makes rudder effect erratic.

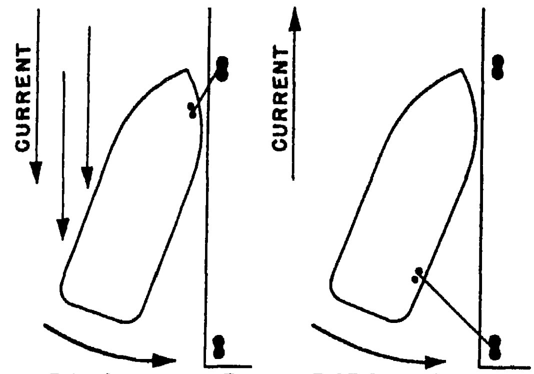

Figure 4-6.—Making use of current.

Using current only: Going alongside by means of current alone is impractical unless there is plenty of room to range ahead or astern. Often the berth will be restricted in size, so the bow must be eased in to go alongside, leaving no room to move ahead. This situation is no particular threat when the current is from ahead; but, in easing the stern alongside, screw and rudder must be used carefully. A following current in an approach to a small berth is much more serious, not only because of the lessened steering effect of the rudder but also because side force from the backing screw combines with current to swing the stern away from the berth. A stern line is imperative in this situation. Outside assistance may possibly be needed.

Short berth: Most single-screw ships maneuvering into a short berth prepare the No. 2 line (after bow spring) on the dockside and get its eye out to the dock as soon as possible (See figure 4-7.) The line is belayed on the No 2 bitts

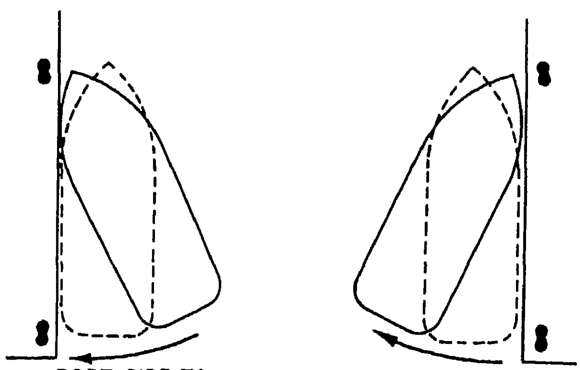

Figure 4-5.—Effect of side force when backing.

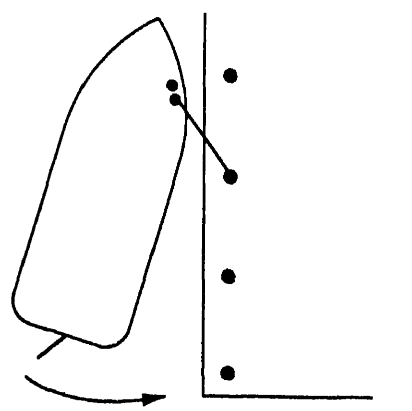

Figure 4-7.—Use of spring line.

on board and is checked carefully as the ship makes headway. The ship should then go ahead on the screws with left rudder on. This combination will swing the stern toward the dock. Care must be taken to avoid parting the spring at this point. If there is too much headway, the screw must be backed to save the spring. Don't forget: Backing will force the stern further off a starboard-side-to berth.

WIND EFFECT

Wind effect is another element to contend with when going alongside. Wind is usually erratic in velocity, and a greater safety margin must be allowed. Remember that the bow and stern may not be equal in sail area, hence wind effect on the ship as a whole will not be distributed uniformly. Another consideration is that, when the ship is approaching the lee side of a berth or another vessel, wind effect at the bow is reduced greatly while wind effect on the stern continues to act with full force. As with current, however, advantage can be taken of the wind if it is blowing toward a berth. Approach should be made so as to stop farther out from the berth than in a no-wind situation, and let the wind bring the ship alongside. Some use of screw and rudder may be required to keep the ship parallel to her berth.

When the wind is setting a ship off her berth, the situation is more difficult. For a port-side-to landing, the pier should be approached at a greater angle than that normally used with slightly more headway A line should be put out to hold the bow, and side force of the backing screw should be used to bring the stern in. To make a starboard-side-to landing, with the wind setting the ship off her berth, again the pier should be approached at a greater angle than normally used with slightly more headway. The bowline and No. 4 (after quarter spring) line should be put out. By going ahead slow on the screw (with full left rudder), side force, rudder effect, and No. 4 line (acting as a spring) will force the stern in against the wind. In such a situation, experienced ship handlers may drop the port anchor to hold the bow. If it is desired to use this method, always check the ship's chart first to ensure that dropping anchor in that area is not prohibited.

Getting Away From a Berth

The next operation to consider is getting underway. Take time to evaluate existing conditions, then plan a line of action. Wind effect should be apparent from the bridge. Current effect, on the other hand, is more difficult to judge. If the ship is moored in a slip, current effect in the immediate vicinity may be completely different from that out in the stream. Throwing a block of wood over the side and noting how it is affected by the current should give an approximate idea what to expect from current action.

Starboard-side-to berth: When possible, the best way to clear a starboard-side-to berth is to back with left rudder. Side force and suction current on the rudder will swing the stern out from the berth so that the ship can back clear safely. If there is no room astern, the stern can be moved out from the dock by using the No. 2 line as a spring and going ahead slow with right full rudder.

Port-side-to berth: Unlike the method of clearing a starboard-side-to berth, trying to back away from a port-side-to landing has a tendency to send the stern against the dock. The best procedure for getting away is to let the No. 2 (after bow spring) line remain out and go ahead with hard left rudder until the stern is clear. The left rudder and the lever effect of the No. 2 line will bring the stern far enough out for the ship to get away, at the same time restricting her forward motion. When the stern is clear, take in the No. 2 line, shift rudder, and back.

Current from ahead: With a strong current running from ahead, a ship probably could clear either starboard-side-to or port-side-to by slacking her head line and letting the current send the bow off. Once it is well off, let go all lines and go out ahead. When the rudder is turned away from the pier, the stern will swing in that direction as the ship goes ahead, especially when leaving a starboard-side-to landing. Only small amounts of rudder should be used until the ship is well clear.

Current from astern: With a current from astern, slacking the stern lines will carry the stern off in the same manner as in the preceding situation. If the ship is in a set direction off the pier, letting go all lines will allow the current to carry the ship broadside out into the stream.

Bank Cushion and Bank Suction

Two other factors that are fundamental in ship handling are bank cushion and bank suction.

With a ship going ahead close and generally parallel to a bank, seawall, or another ship, bank cushion forces the bow out, and suction pulls the stern in. These forces are easily understood if one

considers (1) how the bow funnels water into a narrow area and (2) how screws suck in water from ahead and discharge it astern.

When backing down, the bank effect is reversed. Discharge current from the screws builds up a cushion at the stern, with the result that the stern goes out and the bow goes in.

When going ahead, bank cushion and bank suction can be counteracted by intelligent use of the rudder. Going astern, however, a combination of speed and rudder is required.

Single-Screw Peculiarities

The preceding topics on ship handling merely give an idea of some well known idiosyncrasies of single-screw vessels. This training manual cannot go into detail concerning unusual circumstances wherein a ship will act in a noncharacteristic manner. Habits peculiar to a particular ship must be learned from other conning officers and from experience.

PRECISION ANCHORING

Among the more critical ship-handling evolutions common to all naval vessels is anchoring in the exact center of a predetermined anchorage. It is one of the few instances in which all the piloting and ship-handling skills of the navigator and ship's control team are brought into play. Moreover, it is not enough that the navigator ready the piloting team for the evolution. The navigator must also brief the anchor detail personnel who will handle the ground tackle and the commanding officer and sea detail watch officers who will have the responsibility for ship control. All other personnel who will be concerned with the anchorage must also be apprised of the overall plan and the part they are to play in it.

From the navigator's point of view, much of the effort in anchoring actually is expended before the evolution ever takes place. There are four stages in any successful anchoring, although they may not be formally recognized as such. Those stages are selection, plotting, execution, and postanchoring procedures.

Anchoring Preparation Checklist

An essential part of consistent precision anchoring is adhering to an anchoring preparations checklist that has been developed through experience and is time proven. An example of such a checklist is shown in table 4-3. Whatever checklist you use, you should consider the following additions:

- Make a clear template that has the distance rings on it for the anchoring chart in case the anchor point must be changed quickly.

- After the anchor is determined to be set, use and retain chart overlays of the anchorage to save the chart from excessive wear during prolonged exercises.

Selecting an Anchorage

An anchorage position in most cases is specified by higher authority. Anchorages for most ports are assigned by the local port authority in response to individual or joint requests for docking or visit. Naval ships submit a Port Visit (PVST) request letter or Logistic Requirement (LOGREQ) message well in advance of the ship's scheduled arrival date. Operational anchorages in areas outside the jurisdiction of an established port authority are normally assigned by the senior officer present afloat (SOPA) for ships under his or her command.

If a ship is steaming independently and is required to anchor in other than an established port, the selection of an anchorage is usually made by the navigator and then approved by the commanding officer. In all cases, however, regardless of whether the anchorage is selected by higher authority or by the navigator, the following conditions should always apply insofar as possible:

- The anchorage should be at a position sheltered from the effects of strong winds and current.

- The bottom should be good holding ground, such as mud or sand rather than rocks or reefs.

- The water depth should be neither too shallow, hazarding the ship, nor too deep, facilitating the dragging of the anchor.

- The position should be free from such hazards to the anchor cable as fish traps, buoys, and submarine cables.

- The position should be free from such hazards as shoals and sandbars.

Table 4-3.—Navigation Department Anchoring Checklist

Items marked with an asterisk contain information to be supplied in advance by the Navigator.

INITIALS

1. Anchorage plotted on chart N.O. ____________________ ______
(three copies)

a. *Anchorage point

LAT__________ LONG __________ ______

b. *Anchorage radius__________________ yards__________ ______

c. Letting go circle 50 yards from the anchorage. (The letting go circle will be the position of the periscope beyond the anchorage point when the anchor is let go. ______

d. *Approach track ________________ on ____________ ______
Course NAV AID

e. Range circles at 50, 100, 200, 500, 1,000, 2,000 yards from intersection of track and anchorage point. ______

f. *Select the navigation aids to use in the anchorage: ______

____

____

____

____ ______

g. *The letting go bearing is ____________ on ________ ______
Bearing NAVAID

h. *Select the navigation aid along the track to serve as the heading reference ________________________ ______

i. *Note any hazards, their distance, and bearing·

____

____

____ ______

2. Compute current diagram (Navigation Workbook)

a. Plot Current:

Time:______________________

VELOCITY F_________________________________

E_________________________________

Direction: EBB ______________ FLOOD__________ ______

Table 4-3.—Navigation Department Anchoring Checklist—Continued

INITIALS

b. Current at time of anchoring:

TIME ____________
VELOCITY ____________
DIRECTION ____________
DIRECTION ____________ ________

c. First shift after anchoring:

TIME ____________
DIRECTION ____________ ________

d. Maximum expected current: VELOCITY ____________ knots ________
DIRECTION ____________ knots ________

e. Maximum expected wind: VELOCITY ____________ knots ________
DIRECTION ____________ knots ________

f. Anchor scope ________ FA

3. *List any special considerations or reports from OPORD, SOPA, etc.

____

____

____

4. Assistant navigator review. ________

5. Navigator review. ________

6. Brief the OOD, CO, and ship control party. ________

a. Current and wind
b. Hazards
c. Speed limitations
d. Scope of chain

7. Break out the anchor ball and have it ready to go to the bridge. ________

8. During the final approach

a Verify the log speed is less than 5 knots (one-third bell) ________

b. Letting go bearing with scope operator and bearing recorder (____________). ________

9. At the letting go point, verify the ship is dead in the water or has slight sternway. ________

10. Moored Fix

LAT ____________ LONG ____________ ________

Estimated anchor position from desired anchorage

BEARING ____________ DISTANCE ________ yds. ________

11. Navigation aids to be used (15-minute interval initially):

Table 4-3.—Navigation Department Anchoring Checklist—Continued

INITIALS

a. Visual:

____

____

____

b. Radar:

____

____

____

12. Anchor verified holding properly TIME__________ ________

Required fix interval is ________until__________ ________

● There should be a suitable number of landmarks, daymarks, and lighted navigation aids available for fixing the ship's position both by day and by night.

● If boat runs to shore are to be made, the anchorage chosen should be in close proximity to the intended landing.

Even when an anchorage has been specified by higher authority, the commanding officer, inasmuch as he or she is ultimately responsible for the safety of the ship, has the prerogative of refusing to anchor at the location assigned if he or she judges it to be unsafe. In these circumstances, the commanding officer should request an alternate location less exposed to hazard.

Many of the coastal charts of the United States and its possessions drawn up by the National Ocean Survey contain colored anchorage circles and anchor symbols of various sizes for different types of ships. The circles are located on the chart in those areas best suited for anchoring, taking into account the factors listed above. These circles and symbols are lettered and numbered, allowing a particular berth to be specified. Foreign charts often have anchorage areas specified as well. Amplifying information on possible anchorage sites can be obtained from the applicable volume of the *Coast Pilots*, for U.S. waters; from the proper volume of the *En Route Sailing Directions*, for foreign waters; and from the *Fleet Guide*, for ports in foreign or domestic waters frequented by U.S. Navy ships.

When it is desired to anchor at a location other than that shown as an anchorage berth on a chart, the anchorage is normally specified by giving the range and bearing to it from a charted reference point, along with the radius of the berth.

Plotting the Anchorage

After the anchorage position has been determined, the navigator is ready to begin plotting the anchorage. In so doing, reference is often made to the following terms:

Approach track: This is the track along which the ship must proceed in order to arrive at the center of the anchorage. Its length will vary from 2,000 yards or more for a large ship to 1,000 yards for a ship the size of a Navy destroyer or smaller. Under most circumstances it should never be shorter than 1,000 yards.

Head bearing: If at all possible, the navigator selects an approach track such that a charted navigational aid will lie directly on the approach track if it were extended up to the aid selected. The bearing to the aid thus described is termed the head bearing; it should remain constant if the ship is on track during the approach.

Letting go circle: This is a circle drawn around the intended position of the anchor at the center of the berth, with a radius equal to the horizontal distance from the hawsepipe to the pelorus.

Range circles: These are preplotted semicircles of varying radii centered on the center of the anchorage, drawn so that the areas are centered on the approach track. Each is labeled with the distance from that arc to the letting go circle.

Swing circle: This is a circle centered at the position of the anchor, with a radius equal to the sum of the ship's length plus the length of the chain let out.

Drag circle: This is a circle centered at the final calculated position of the anchor, with a radius equal to the sum of the hawsepipe-to-pelorus distance and the final length of chain let out.

The actual radii of both the swing and drag circles will in reality be less than the values used by the navigator in plotting them on the chart, because the catenary of the chain from the hawsepipe to the bottom is disregarded. Thus, a built-in safety factor is always included in the navigator's plot.

Before commencing the anchorage plot, it is always wise to draw a swing circle of estimated radius around the designated anchorage site to check whether any charted hazards will be in close proximity to the ship at any time as it swings about its anchor. If any such known hazards are located either within or near the swing circle, an alternate berth should normally be requested.

If the anchorage appears safe, the navigator begins the anchorage plot by selecting the approach track. During this process, due regard must always be given to the direction of the predicted wind and current expected in the vicinity of the anchorage. Insofar as possible, the approach should always be made directly into whichever of these two forces is predicted to be strongest at the approximate time at which the anchorage is to be made.

The letting go circle is drawn with a radius equal to the horizontal distance between the anchor-hawsepipe and the pelorus, from which bearings will be observed. If the anchor were not let go until the pelorus was over the center of the assigned berth, the anchor would miss the center by the length of the ship from the hawsepipe to the pelorus. Thus, when the letting go bearing, measured from the intersection of the letting go circle and the approach track, is observed on the pelorus, the anchor will be in position directly over the center of the assigned berth.

The anchorage plot is completed by laying down the remainder of the intended track leading up to the approach track, and then swinging the range circles across the track. These arcs are normally drawn at 100-yard intervals measured outward from the letting go circle to 1,000 yards, and at ranges of 1,200, 1,500, and 2,000 yards thereafter. After the anchor has been let go and the chain let out to its final length, a second swing circle is plotted, followed by the drag circle.

The use of these various quantities is best illustrated by an example. Suppose that a ship having a total length of 300 feet (100 yards) and a hawsepipe-to-pelorus distance of 150 feet (50 yards) has been directed to anchor at the position specified in the bay pictured in figure 4-8.

After an estimated swing circle has been plotted and the anchorage has been determined to be safe, the navigator is ready to begin the construction of the anchorage plot. As the first step, the approach track is selected by considering the different objects available for a head bearing, taking into account the expected winds and current in the bay. Assuming negligible current and a northernly wind, the tower in figure 4-8 is a good choice for a head bearing, especially since it is doubtful that an approach track of sufficient length could be constructed using any other navigation aid shown. The approach track is then laid off from it, as in figure 4-9.

As the next step, the intended track leading to the final approach track is laid down, with care being taken to allow for the proper length for the approach track. It is assumed here that the ship will be approaching the bay from the southwest. The advance and transfer for the 60-degree left turn onto the approach track are obtained, and the turning point is located. A turn bearing

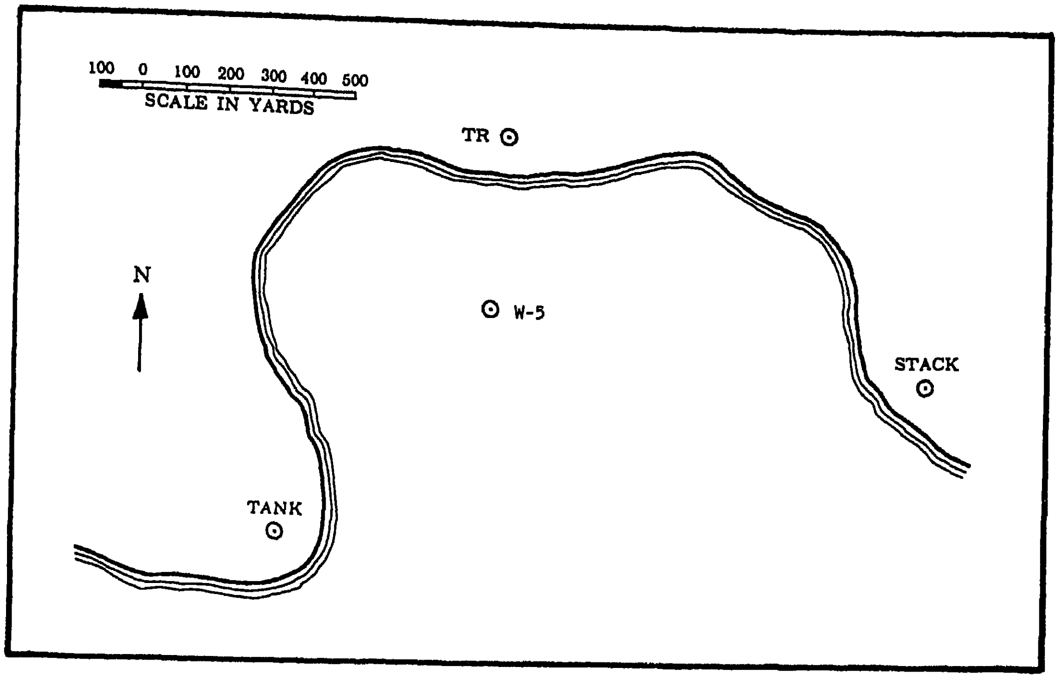

Figure 4-8.—An anchorage assignment.

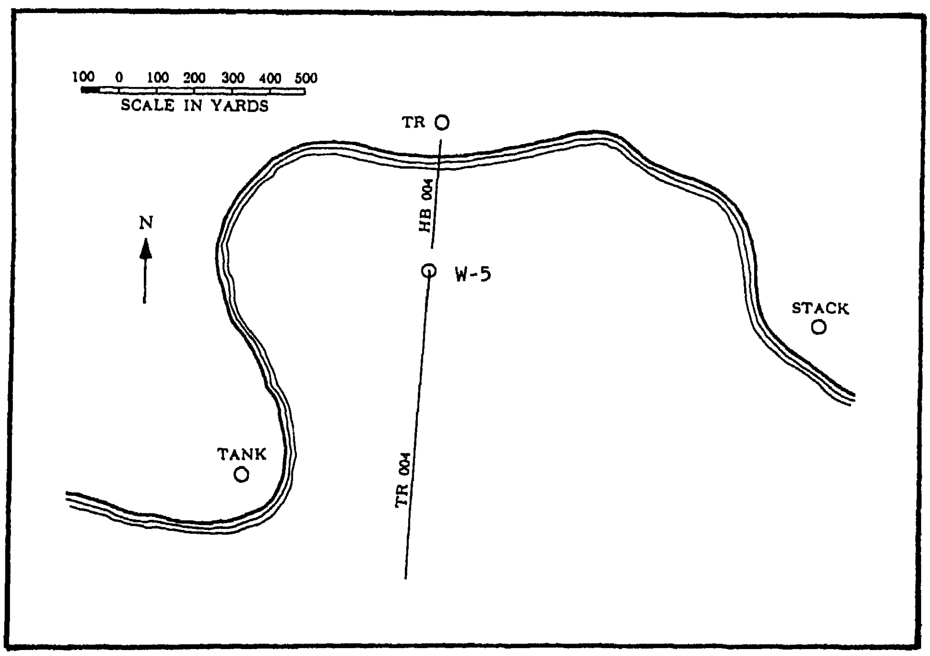

Figure 4-9.—Laying down the approach track.

drawn from this point and labeled. At this stage, the plot appears as in figure 4-10.

To complete the plot,.the letting go circle is drawn, with a radius equal to the 50-yard hawsepipe-to-pelorus distance. The letting go bearing is then constructed using the stack, as it is nearly at a right angle to the approach track. Finally, range circle arcs are drawn and labeled, centered on the middle of the anchorage, with radii measured in 100-yard increments outward from the letting go circle to 1,000 yards. Arcs are also swung for 1,200-, 1,500-, and 2,000-yard distances to the letting go circle (the last of these is not shown in figure 4-10, because of space limitations). The anchorage plot is now complete and appears as shown in figure 4-10.

The various arcs, bearings, and tracks are drawn as shown to make the reading of

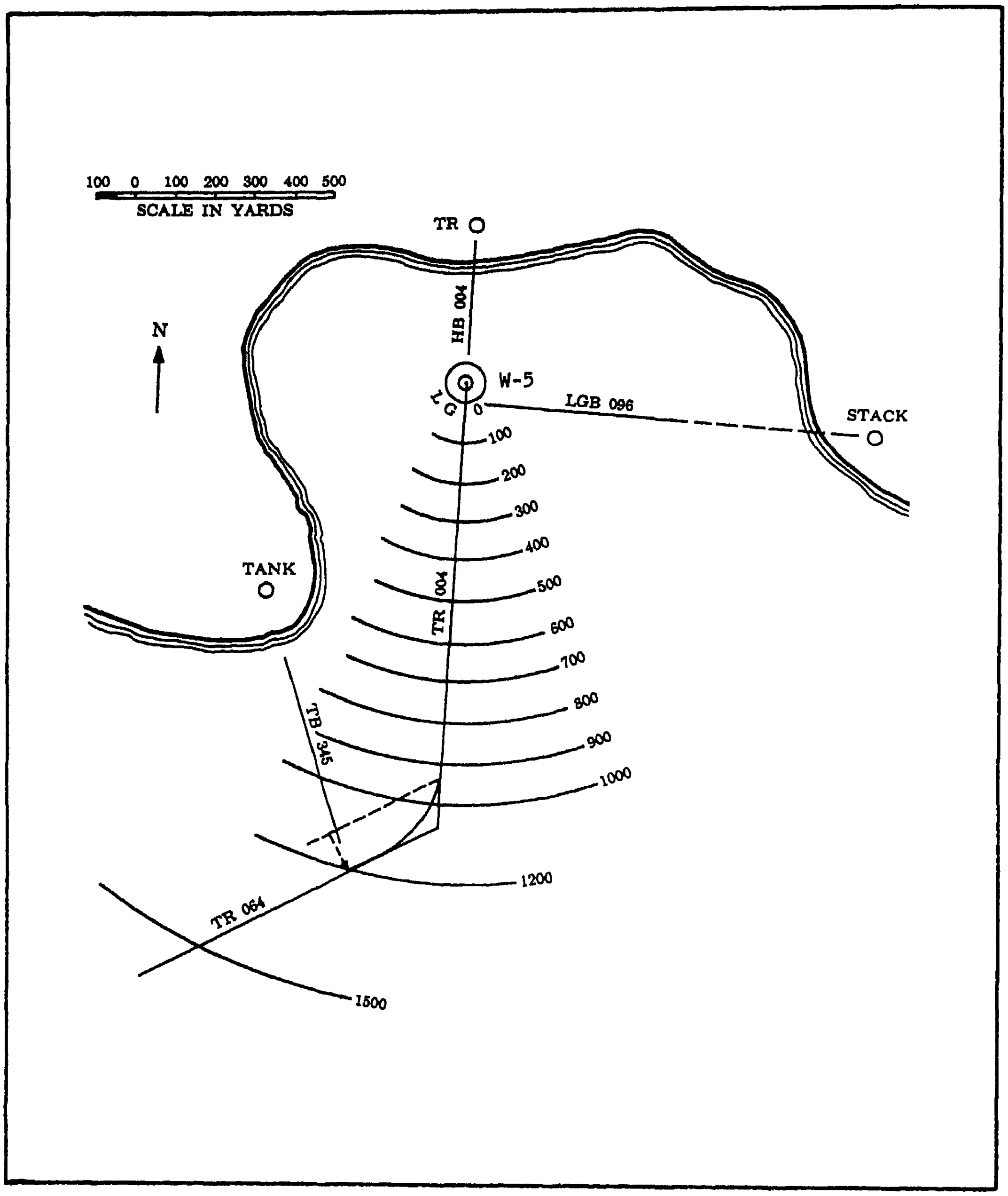

Figure 4-10.—The completed anchorage plot.

information from the plot fast and easy for the navigator as the ship is approaching its anchorage. The navigator will already have briefed the captain, conning officer, and pilot if aboard as to the intended head bearing and letting go bearing; they could then drop anchor in the proper location without further word from the navigator by keeping the head bearing always constant and dropping anchor when the letting go bearing reached the proper value. The navigator does not remain silent during this time, however. Quite to the contrary, he or she obtains fixes as often as possible and maintains a running commentary to inform all concerned as to the distance to go to the drop circle and whether the ship is to the right or to the left or in the approach track as it proceeds to the anchorage.

Executing the Anchorage

When executing the actual anchorage, the navigator's dual objective is to keep the ship as near as possible on its preplanned approach track and to have all headway off the ship when the hawsepipe is directly over the center of the anchorage. As mentioned above, the navigator obtains frequent fixes as the ship proceeds along its track, and keeps the bridge continually informed as to the position of the ship in relation to the track and the letting go circle. The navigator recommends courses to get back onto track if necessary. Since every ship has its own handling characteristics, speeds that should be ordered as the ship proceeds along the track are difficult to specify. In general, however, with 1,000 yards to go, most ships are usually slowed to a speed of 5 to 7 knots. Depending on wind and current, engines should be stopped when about 300 yards from the letting go circle, and the anchor detail should be instructed to "stand by." As the vessel draws near the drop circle, engines are normally reversed so as to have all remaining headway off the ship as it passes over the letting go circle. When the pelorus is exactly at the letting go bearing, the word, "Let go the anchor" is passed to the anchor detail, and the anchor is dropped.

As the anchor is let go, the navigator should immediately call for a round of bearings to be taken, and he or she should record the ship's head. After the resulting fix is plotted, a line is extended from it in the direction of the ship's head, and the hawsepipe-to-pelorus distance is laid off along the line, thus plotting the position of the anchor at the moment that it was let go. If all has gone well, the anchor should have been placed within 50 yards of the center of the anchorage.

Postanchoring Procedures

After the anchor has been let go, the chain is let out or "veered" until the length or "scope" of chain five to seven times the depth of water is reached. At this point, the chain is secured and the engines are backed, causing the flukes of the anchor to dig into the bottom, thereby "setting" the anchor.

When the navigator receives the word that the chain has been let out to its full precomputed length and that the anchor appears to be holding with a moderate strain on the chain, he or she agains records a round of bearings and the ship's head, as well as the direction in which the chain is tending. With this information, the navigator plots another fix and recomputes the position of the anchor by laying off the sum of the hawsepipe-to-pelorus distance plus the scope of chain in the direction in which the chain is tending. This second calculation of the position of the anchor is necessary because it may have dragged some distance from its initial position during the process of setting the anchor.

After the final position of the anchor has been thus determined, the navigator then draws a second swing circle. This time the navigator uses the computed position of the anchor as the center, and the sum of the ship's length plus the actual scope of chain let out as the radius. If any previously undetermined obstruction, such as a fishnet buoy or the swing circle of another ship anchored nearby, is found to lie within this circle, the ship may have to weigh anchor and move away from the hazard. If the ship is anchored in a designated anchorage area, due care should be taken to avoid fouling the area of any adjacent berths, even though they might presently be unoccupied. If the swing circle intersects another berth, it may be necessary to take in some chain to decrease the swing radius; if this is not possible, a move to a larger berth may be advisable.

If the navigator is satisfied that no danger lies within the swing circle, he or she then draws the

drag circle concentric with the swing circle, using as a radius the sum of the hawsepipe-to-pelorus distance plus the scope of chain. All fixes subsequently obtained should fall within the drag circle; if they do not, the anchor should be considered to be dragging. Both the swing circle and drag circle are shown in figure 4-11, assuming that a scope of chain of 50 fathoms to the hawsepipe has been let out.

After plotting the drag circle, the navigator then selects several lighted navigation aids suitable for use in obtaining fixes by day or night and enters them in the bearing book for use by the anchor-bearing watch. The anchor-bearing watch is charged with obtaining and recording in the bearing book a round of bearings to the objects designated by the navigator at least once every 15 minutes, and plotting the resulting fix on the chart each time. Should any fix fall outside the drag circle, another round of bearings is immediately obtained and plotted. If this second fix also lies outside the drag circle, the ship is considered to be dragging anchor, and all essential personnel are alerted.

In practice, as previously mentioned, if the ship is to be anchored for any length of time, the navigator will usually have the anchor watch cover the area of the chart containing the drag circle with a sheet of semiclear plastic. This is done so the chart will not be damaged by the repeated plotting and erasures of fixes within the drag circle.

The importance of maintaining a competent and alert anchor watch cannot be overemphasized, as many recorded groundings have occurred because the duties of this watch were improperly performed. When a ship is dragging anchor, especially in high wind conditions, there is often no unusual sensation of ship's motion or other readily apparent indication of the fact. The safety of the ship depends on the ability of the anchor watch to accurately plot frequent fixes and to alert all concerned if they begin to fall outside the drag circle. If conditions warrant, the ship may have to get underway. As interim measures to be taken while the ship is preparing to do this, more chain may be veered to increase the total weight and cantenary of the chain in the water, and a second anchor may be dropped if the ship is so equipped.

In situations in which high winds are forecast, the ship should assume an increased degree of

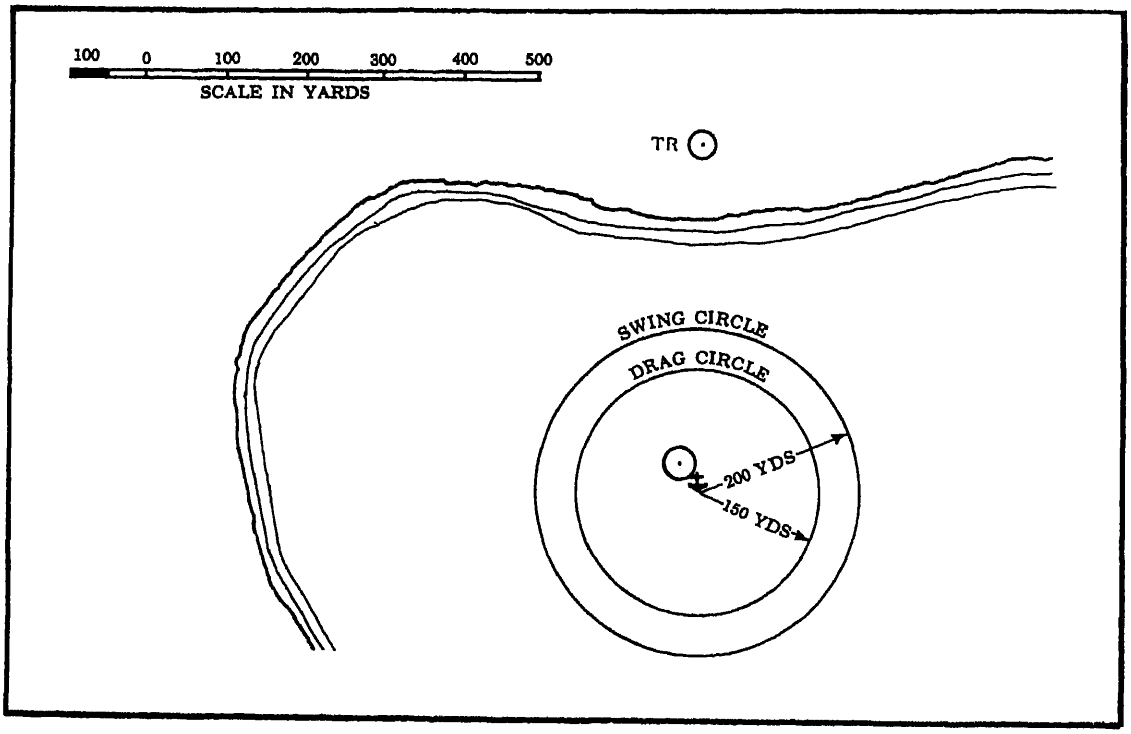

Figure 4-11.—An expanded view of the swing and drag circles.

readiness, with a qualified conning officer stationed on the bridge, and a skeleton engineering watch standing by to engage the engines if necessary. As an example, during a Caribbean cruise a U.S. Navy submarine was anchored of St. Thomas, V.I., in calm waters and with less than 5 knots of wind blowing. Because high winds had been forecast for later in the night, the OOD was stationed on the bridge and a skeleton engineering watch was charged with keeping the engines in a 5-minute standby condition. Two hours after anchoring, after the liberty sections had gone ashore, the wind began to increase. In the next 45 minutes, wind force increased to the point where 55-knot gusts were recorded. The ship got underway and steamed throughout the night until the storm abated the next day.

UNDERWAY OPERATIONS

Common to all U.S. Navy vessels are underway operations. Whether by design, as the result of scheduling or planning, rapid response, or emergency situations, your response and divisional performance are critical. Because a considerable number of publications and manuals govern underway operations, addressing each is beyond the scope of this manual. A few examples common to all naval units are discussed, along with a general discussion on tactical procedures and elements.

TACTICAL COMMUNICATIONS

Tactical communications are the means by which an officer in tactical command (OTC) coordinates and controls the movements of units under his or her command, primarily by either visual or radiotelephone (R/T) messages. Flashing light and flaghoist are used extensively during daylight when units are within visual range, while radiotelephone is used when visual signaling is impractical. R/T is the least secure method of transmission, being subject to interception at great distances by anyone having suitable equipment.

There are three principal tactical communication stations aboard ship: the bridge (pilothouse), signal bridge, and combat information center (CIC). Liaison is maintained between these stations via internal ship' communications systems. The signal bridge is responsible, under the OOD, for visual traffic. R/T tactical circuits (both primary and secondary) are controlled by the bridge, but they are also guarded and all messages recorded in CIC as a backup for the OOD. Aboard flagships, all tactical communications are controlled by the embarked staff communications officer or staff watch officer.

Communication methods are discussed, including refresher material from the *Quartermaster 3* TRAMAN, plus some advantages and disadvantages of each method.

Flashing Light

Flashing light tactical communication employs visible and infrared light beams to transmit Morse code characters. (Infrared is used only at night. Visible flashing light may be used at night in peacetime.) Both directional and nondirectional transmissions are possible.

Standard Navy searchlights fitted with hand-operated shutters are used for directional signaling. Nondirectional signaling uses yardarm blinkers (one on the end of each yardarm), operated by a telegraph key

For directional infared signaling, a hood having a special lens is fitted to the searchlight. The light is operated in the usual manner, but the searchlight must be aimed toward the receiver for accuracy For nondirectional signaling there are two infared beacons mounted either inboard of the yardarm blinkers or on a separate support on the mast. They can operate in the same manner as the blinkers, or they can provide a steady light as a point of train on which other ships train their lights for directional infared signaling Although infared signaling requires special viewing equipment and precise signal light aiming, it is especially useful in wartime because of the security provided. When a ship desires to communicate with another via infared signaling, she transmits "Nancy Hanks" over a radiotelephone circuit.

Tactical signals may be sent by flashing light, but because of the need to relay the signals to outlying units, their execution becomes more difficult as the number of ships increases. Nondirectional signaling eases the task, but the

range is not as great as directional signaling, and visible light cannot be used at night in wartime.

When flashing light is used for tactical signals, the executive method is employed. In the delayed executive method, the signal is receipted for by receiving stations, and the signal is executed by a later transmission. In the immediate executive method, only one transmission is made—the signal is sent twice, then executed. In both methods the moment of execution is the termination of a 5-second flash.

Flaghoist

Flaghoist signaling provides a rapid, accurate, and relatively secure means of handling tactical and informational signals, during daylight, between ships in proximity.

It is rapid because one ship, hoisting one or more flags having a predetermined meaning, can communicate simultaneously with several other ships. It is accurate because all addressees are required to repeat the signal, thus allowing the originator to make sure they have read the signal accurately. A reasonable degree of security is achieved due to visibility range limitations.

For allied signaling, the flags and pennants shown in the QM3 TRAMAN are used. For international signaling only the alphabet flags, the numeral pennants, the CODE/ANSWER pennant, and the substitutes (except the fourth) are used.

The most common locations (points of hoist) of signal halyards are the masthead and the yardarms on the foremast. Some ships use a triatic stay, which is a line running fore and aft between the mast and stack, or similar points.

Signals are read from the top down, and when flying from the yardarm, from outboard in. Those flying from the triatic stay are read from forward aft. When displays are flown from different points of hoist, they are read in the following order: masthead, triatic stay, starboard yardarm, port yardarm. With yardarms of different heights, the higher one is read first.

In transmitting a flaghoist signal, the originator hoists the flags close up. Addressees hoist the same signal at the dip, indicating that the signal has been received but not yet decoded. Both the OOD (or JOOD) and CIC decode the signal, and CIC informs the bridge of the signal's meaning as a backup to the OOD's interpretation. The OOD then orders the signalmen to acknowledge, which is done by hoisting the flags close up. When all addressees have acknowledged the signal, the originator hauls his display down. If it is a maneuvering signal, that is the moment of execution unless a time of execution has been specified.

Quite often there are ships that cannot see the OTC's (or other originator's) ship, or cannot read his flaghoist signals. In such situations it is the responsibility of ships in positions to do so to relay messages to other ships in the direction away from the originating ship. Although ships may be designated "repeating ships," it is the duty of any ship to relay signals when it is evident that she is in a better position to do so than a ship specifically responsible. A relaying ship may not acknowledge a signal until ships to which she is relaying have done so.

Radiotelephone

Radiotelephone (voice radio) provides the only "real time" means of communication among units. Because of its directness, convenience, and ease of operation, voice radio is used extensively between ships and between ships and aircraft for short-range tactical communications

There can be certain drawbacks to using voice radio. There is no transmission security, which means that anyone having the proper equipment can intercept signals; and poor voice communications, whether because of faulty equipment, adverse atmospheric conditions, or inept performance by an operator, can create confusion, reduce reliability and speed, and adversely affect operations. It is essential, therefore, that all users strictly observe established operating procedures.

Basic guidance for voice radio communications is contained in *Communications Instructions, Radiotelephone Procedures*, ACP 125. Various naval warfare publications (NWPs) and allied tactical publications (ATPs) prescribe procedures for specific environments (AAW, ASW, NGFS, etc.).

Security

In the interest of security, transmissions by radiotelephone should be as short and concise as possible, consistent with clearness. All operators must be cautioned that transmissions by radiotelephone are subject to enemy interception and, therefore, have no security.

The following basic rules are essential to transmission security and are to be strictly enforced on all military radiotelephone circuits.

1. No transmission will be made that has not been authorized by proper authority.

2. The following practices are specifically forbidden:

   Violation of radio silence.

   Unofficial conversation between operators.

   Transmitting on a directed net without permission.

   Excessive tuning and testing.

   Transmitting the operator's personal sign or name.

   Unauthorized use of plain language in place of applicable prowords or operating signals.

   Linkage or compromise of classified call signs and address groups by plain language disclosures or association with unclassified call signs.

   Profane, indecent, or obscene language.

3 The following practices are to be avoided:

   Use of excessive transmitting power.

   Excessive time consumed in tuning, changing frequency, or adjusting equipment.

   Transmitting at speeds beyond the capabilities of receiving operators.

SIGNAL BOOK

The origin of most tactical signals is the *Allied Maritime Tactical Signal Book*, ATP 1C, volume II, commonly referred to as the signal book. Its primary purpose is the dissemination of orders and information pertinent to allied naval operations. Although the signal book may be used with any method of signaling, it is used mainly with flaghoist and radiotelephone.

The overall security classification of ATP 1C, volume II is Confidential. Because a simple unchanging code is used, however, the groups themselves have no security. Care must be taken, therefore, not to transmit classified information when there is danger of its interception.

The signal book is divided into three sections: instructions, signal vocabulary, and index. Its 33 chapters are constituted as follows:

Chapter 1	General instructions for use of the book
Chapter 2	Single flags and pennants
Chapter 3	Emergency alarm and emergency action signals
Chapter 4-9	Maneuvering signals utilizing special flags and pennants
Chapter 10-33	Operational and administrative signals; special tables

The operational and administrative signal chapters are arranged alphabetically under appropriate headings, with the basic signal group consisting, when possible, of the first two letters of the chapter title (e,g, Administrative—AD; Meteorology—ME) When this is not possible, a self-evident group is assigned (Antisubmarine Warfare—AS; Electronic Warfare—EW).

ENCODE/DECODE

To encode a signal, reference should be made to the index, which lists key words of the desired signal, together with the basic signal group and a chapter/page number reference. The meanings in the index are not complete; instructions have been omitted and only the basic signal is given.

For this reason the index should not be used separately for encoding.

When appropriate, cross-indexing is used, thus making available several key words for a particular subject. For example, the basic signal for indicating the number of helicopters assigned to a screen can be found under "helicopters," "number," and "screen."

To decode a signal, reference should be made to the single flag and pennant chapter, special pennant chapter, or main signal vocabulary, as applicable, for the basic signal.

SIGNAL CONSTRUCTION

Messages transmitted by flaghoist consist, with certain exceptions, of a heading (call) and a text. Unless a signal from a superior is addressed to an individual unit within a group, the heading is omitted, with the understanding that the signal is addressed to all ships. When a junior hoists a signal with no call, it is addressed to the superior.

Signals from chapters 4 through 9 are preceded by the appropriate special flag or pennant if action is required. If the message is one of information, the flag or pennant follows the signal.

Some signals require information in addition to the basic group. Where "_____" or "as indicated" appear, the signal must be completed by adding the required data from a list of suffixes accompanying the basic group. When the instruction is in parentheses, the addition of supplement information is optional.

The *QM3* TRAMAN details signal construction and radiotelephone procedures in more detail, and they will not be reviewed here. Call signs and signals to be used in the remaining sections of this chapter are to be considered fictitious.

TACTICAL MANEUVERING AND PLOTTING

It is not unusual for naval ships to steam in company—that is, for two or more ships to proceed together from one locality to another. For mutual protection and to reduce the risk of collision, these ships usually arrange themselves in a formation. There are numerous types of line and circular formations, as well as various types of screens, surface action groups, and dispositions. In general, the type of formation chosen by the OTC for a group of ships depends on the number and classes of ships participating and on the tactical situation. Types of formations, maneuvering systems, and rules for ordering and maneuvering formations are found in ATP 1C, volumes I and II.

TYPES OF FORMATIONS

The basic, simple formations used by naval ships are as follows:

- The line formation, which includes column, abreast, and bearing lines formed from or to the guide

- The circle formation, which uses bearing and range from or to the guide, in a circular pattern

Other, more complex, formations are used by the Navy; however, they are classified and therefore will not be discussed in this book. Details about these formations are found in ATP 1C, volumes I and II.

Formation Plot

Maneuvering board problems in change of station and closest point of approach (CPA) are described in *Quartermaster 2* TRAMAN. The problems presented in that training course deal exclusively with a guide (or reference ship) and one other ship (maneuvering ship). Formations, on the other hand, are usually composed of a guide and several other ships. When numerous ships are involved, the methods of changing station are the same as when only one ship must maneuver except that each ship must avoid risk of collision with the others.

When you are constructing a formation plot, the position of the guide usually is plotted first in the center of the maneuvering board. Ranges and bearings of other stations are plotted relative to the guide.

In circular formations, the station in the center is called station zero. Circles (on the status board

or maneuvering board) are numbered consecutively, outward from the center. Unless otherwise ordered, circle spacing is 1,000 yards. Thus, a circle with a radius of 5,000 yards is known as circle 5; one of 5,200 yards is known as 5.2. The location of a station is described by the number of the circle on which it lies, followed by its direction, relative to the axis, measured clockwise from 000° to 359°. (The axis is the true bearing from the center around which a formation is oriented. It may or may not coincide with the formation course.) An example of a station designation is station 2A: 4,5090. In this example, station 2A would be plotted 4,500 yards (to scale) from the center of the circle, 90° relative to the axis.

Formations may be plotted with station zero or the guide in the center, or with own ship in the center as it would ordinarily appear on a plan position indicator (PPI) scope. Figure 4-12 is an example of a formation diagram

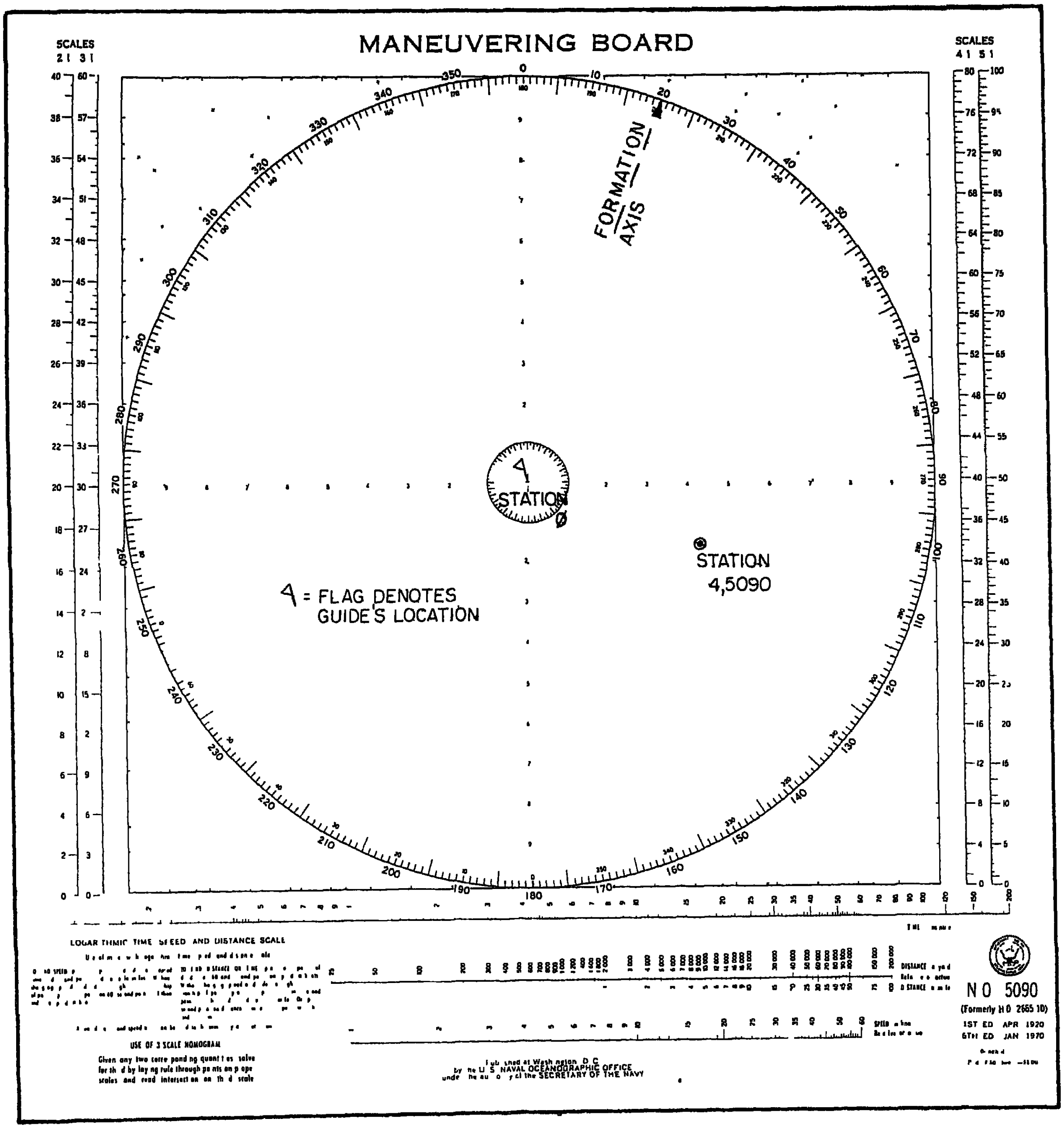

Figure 4-12.—Formation diagram with guide (station 0) at the center.

with the guide (station zero) at the center. Figure 4-13 shows the same formation on a status board with own ship at the center. When formations are plotted as in figure 4-13, the range and bearing from own ship to any other ship may be obtained by inspection alone.

Principles of Station Keeping

Regardless of the type of formation being maintained, each participating ship is assigned a specific station relative to an assigned guide and to other ships in the formation. Inasmuch as ships react differently to conditions such as wind, current, rudder drag, and water resistance, ships that are theoretically steaming on exactly the same course and speed will not indefinitely retain their positions relative to one another. The guide must maintain the course and speed designated by the OTC, and other ships must keep station, position, on the guide by what is known as station keeping.

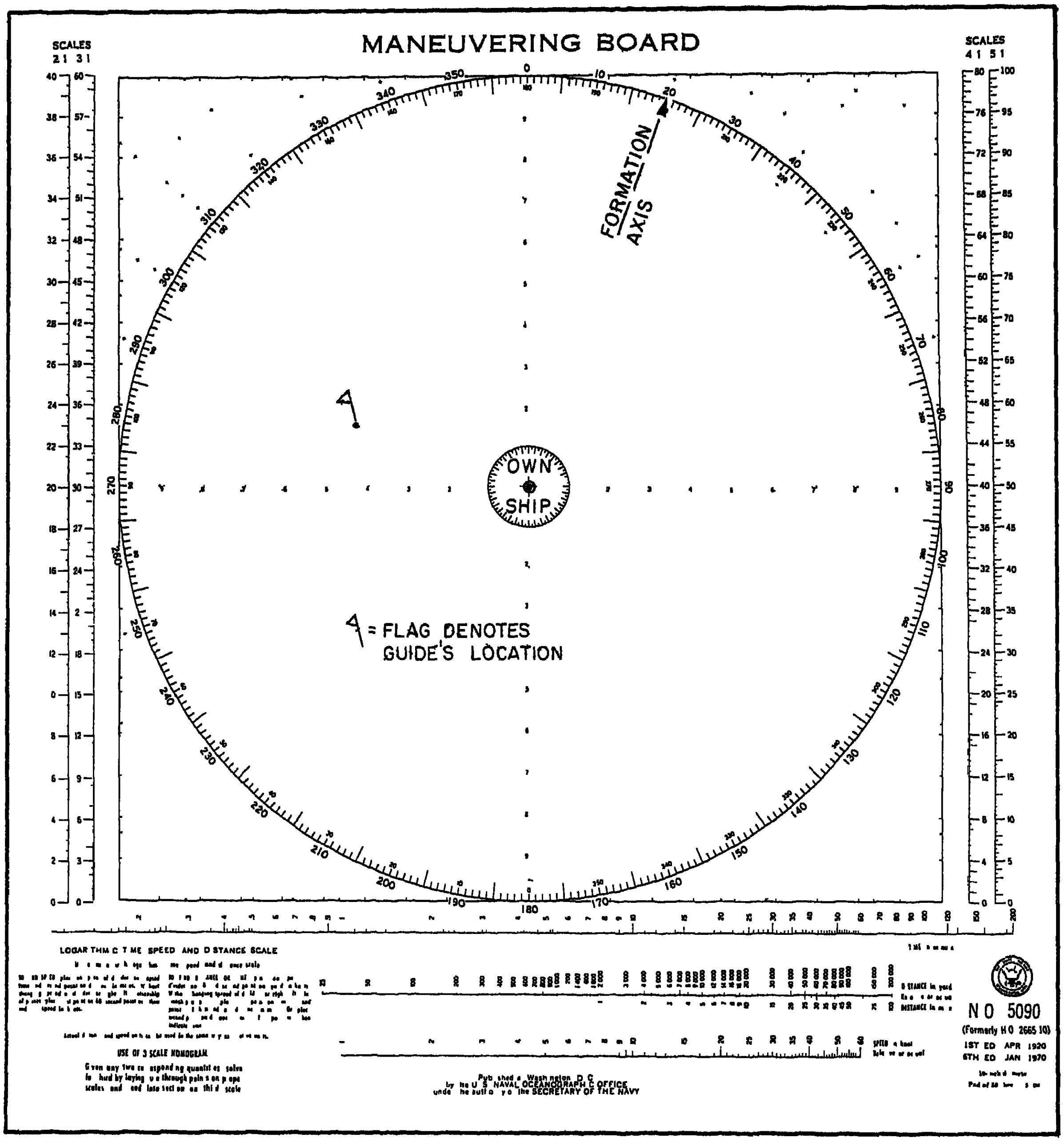

Figure 4-13.—Formation diagram with own ship at center.

Because a station is located by its bearing and range from the guide, the basis for good station keeping is a continuous and accurate determination of the guide's range and bearing. Risk of collision is always a threat when ships are in formation; consequently, the importance of exact station keeping cannot be overemphasized.

In each type of formation, different techniques are used to keep station. These techniques are discussed later in this chapter, but first, some basic information on stations:

Types of formations are normally ordered using coded signals from ATP 1C, volume II, which may include the true or relative bearing from the guide along which ships are to take station. For a ship that is keeping station on the guide, the prescribed bearing from the guide is converted to a reciprocal, which is used continuously to check position.

Range or distance prescribed for a particular formation is the distance to be maintained between the guide and other ships of the formation. Range is checked repeatedly, using either a stadimeter or sextant (in daylight) or radar.

Courses and speeds may be included in an operation order, or they may be signaled. As mentioned before, the guide assumes the signaled course and speed. Individual ships must make adjustments in their courses and speeds to keep station on the guide.

It is much easier to maintain a reasonably accurate station than it is to regain position after losing it. It is better, therefore, to make immediate small changes in course and speed to correct position than to wait until position error is so great that radical changes are required.

When a ship is in line with the guide (either directly ahead or astern), station keeping is relatively simple. Distance is adjusted by changing own ship's course. Bearing is adjusted by altering own ship's course.

When a ship is in a line abreast (directly abeam) of the guide, distance is adjusted by changing own ship's course. Bearing is adjusted by changing own ship's speed. In this situation a course change will have slight effect on bearing; a speed change will have slight effect on distance. These effects usually are so small as to be negligible. If, however, they become appreciable, they may be corrected by using a combination of course and speed changes. (In this situation, a maneuvering board solution may be advantageous.)

Adjusting bearing or range is somewhat more complex when the station is neither directly ahead or astern nor abeam of the guide, because a combination of course and speed changes usually is necessary to adjust either bearing or range. A keen understanding of relative movement and the ability to visualize the ship's situation are essential to this type of station keeping.

Turning away from the guide usually opens the range, but the effect on bearing depends on whether the ship is to port or starboard of the guide and whether forward or abaft the beam. Figure 4-14 shows ships in various positions relative to the guide. The arrows indicate the effects of a 20° course change with no change in speed. Note that a different result in range and bearing is obtained from each relative position. (It will probably never be necessary to change course 20° solely to maintain station. In figure 4-14, 20° is used only for illustrative purposes.) As can be seen, a speed change is needed to offset each course change. The situation is similar when speed is changed; then, each speed change must be offset by a course change.

Maneuvering Examples

Combining the basic information addressed in the QM3 and QM2 TRAMANs and the aforementioned material, your ability to solve seemingly difficult maneuvering board problems are greatly reduced. Complex problems are solved by breaking them into simpler, singular problems, one step at a time. The following maneuvering board problems provide definitions and solutions.

1. Formation axis rotation: The primary advantage of circular formation is the ability to reorient ships about the guide without assigning new station numbers to the individual ships. Axis rotation may be required for any of several reasons, e.g., to reorient units toward the enemy or to arrange more efficiently for conducting flight operations. Since the bearing of each station is designated by its relative bearing from the axis, each station with the exception of the guide's must rotate in the same direction and by the same amount as the axis in order to keep its relative bearing from the axis constant. The guide is always considered to be on station, and maintains course and speed during an axis rotation, so that other ships in the formation may have a constant reference from which to determine their own position by true bearing and range to the guide. When the formation axis is rotated, the TRUE bearing from a ship to the guide changes by the same amount and in the same direction as the axis rotates. The range to the guide remains the same.

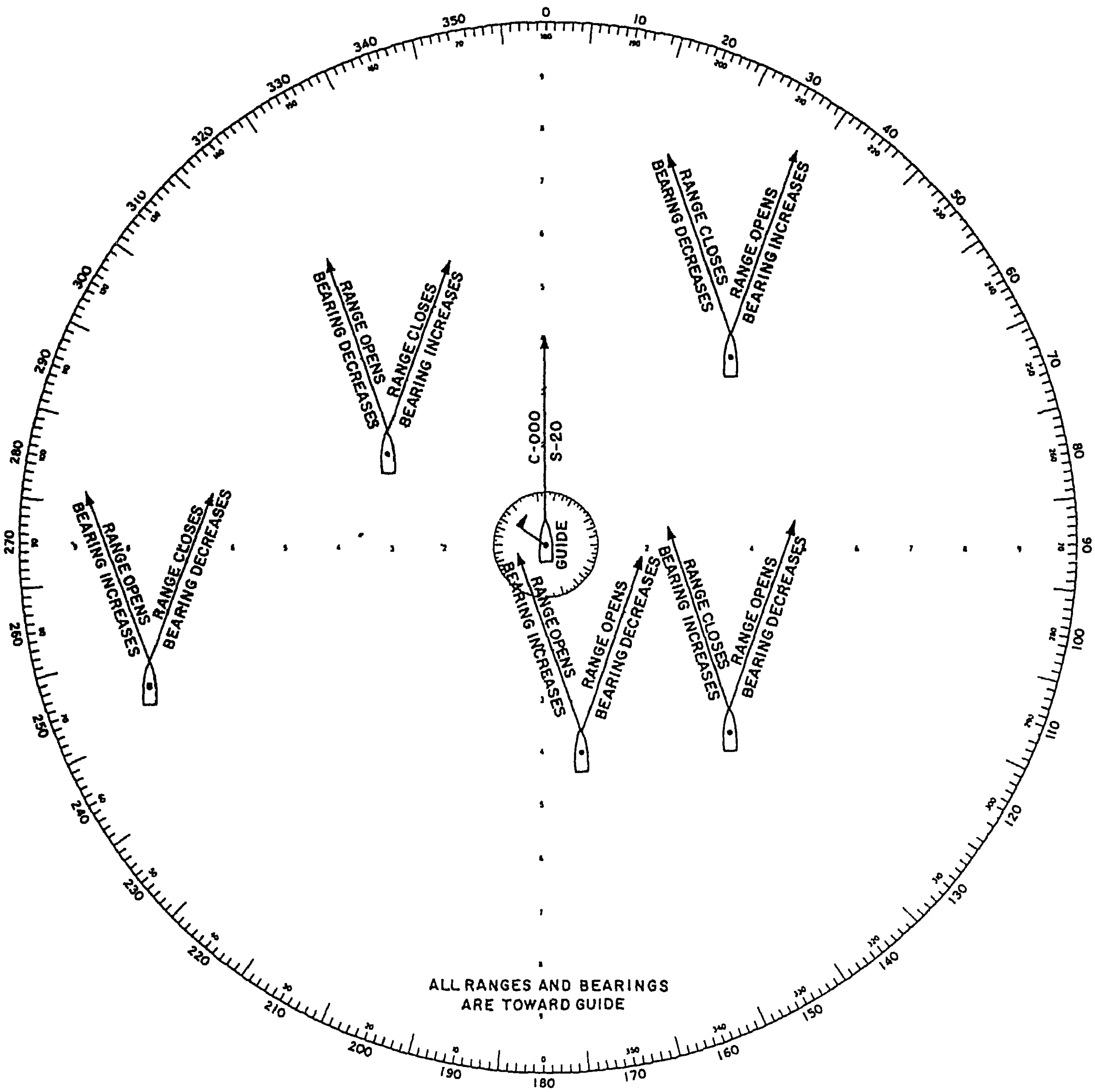

Figure 4-14.—Result of course change in station keeping

This is true regardless of whether or not the guide is at the center of the formation.

An axis rotation problem is similar to a change of station problem; although own ship's station assignment remains the same, a maneuver is necessary to regain that station when the axis is rotated. The key point is this: the entire formation rotates around the formation guide rather than the formation center; the guide is always considered to be on station. All ships keep station on the guide by maintaining a true bearing and range to him. There are two basic types of axis rotation problems: with the guide in the center of the formation, and with the guide out of the formation center. However, the basic rules governing axis rotation apply to both cases.

Situation: Formation course is 240°T; formation speed is 15 knots. The formation axis

is 130°T. The guide is in station zero, and your station, 5X, is 6330. Stationing speed is 20 knots. The OTC orders the formation axis rotated to 070°T.

Required:
1. The true bearing to the guide before axis rotation
2. The true bearing of the guide after axis rotation
3. The range to the guide after axis rotation

Required—Continued
4. Your course to station
5. Time to complete the maneuver
6. Range and bearing of the guide at CPA

Solution: Solving this problem requires recognizing that it is a combination of two separate problems. First, change of station due to an axis rotation, and second, solving for CPA. Figure 4-15 illustrates the entire

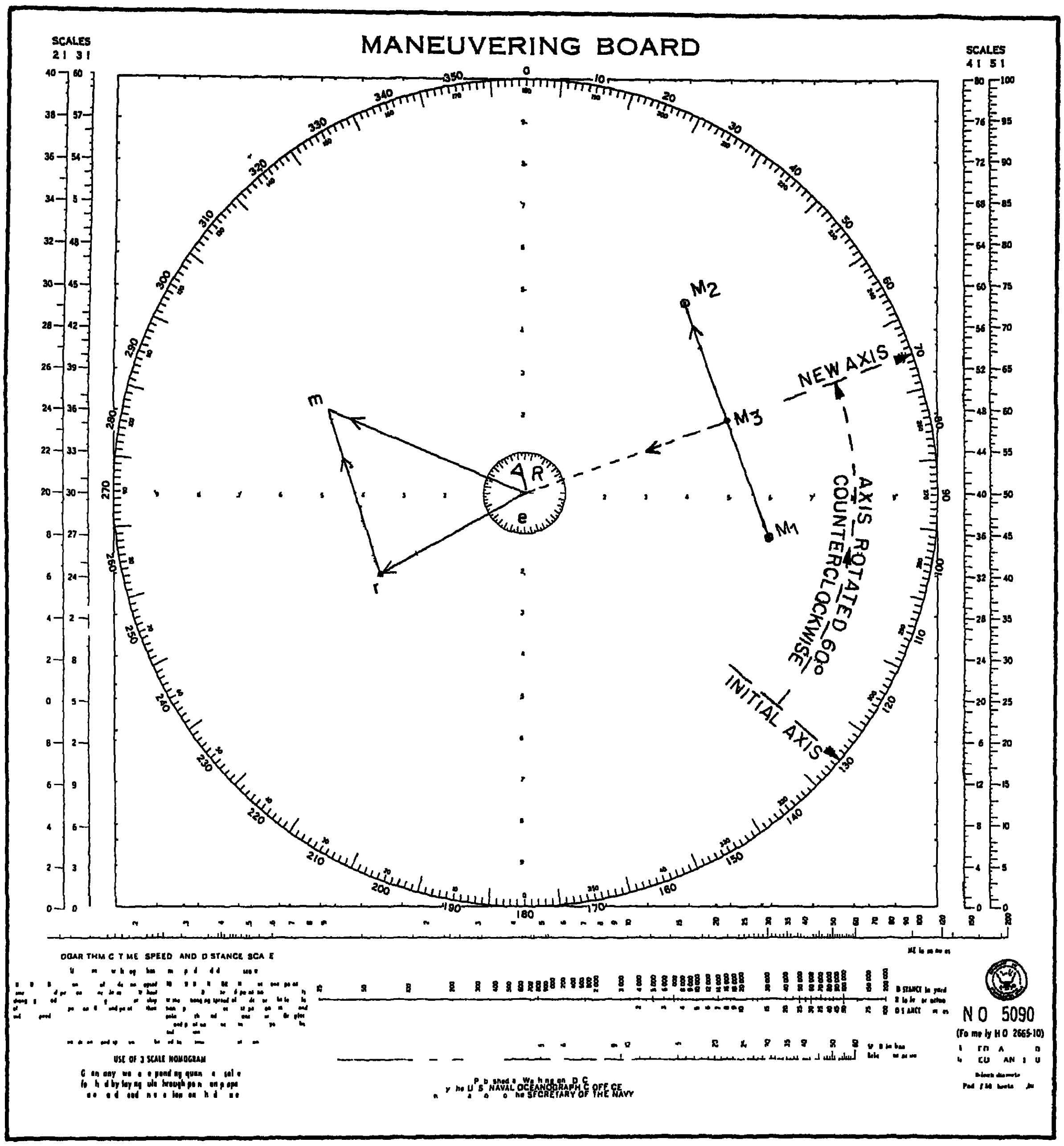

Figure 4-15.—Formation axis rotation—guide in center.

evolution, with appropriate symbology and annotations.

Answers: 1. 280°T

2. 220°T

3. 6,000 yards

4. 292.5°T

5. 11.2 minutes

6. 250°T, 5,250 yards

2. Passing No Closer Than: This type of maneuver is usually reserved for restricted maneuvering operations, such as proceeding to plane guard station for conducting flight operations or proceeding to replenishment station.

Situation: The formation is on course 240°T, speed 18 knots. The guide now bears 350°T, range 5,000 yards. You are ordered to take station bearing 000°T, range 4,000 yards from the guide. OTC orders you to pass astern of the guide no closer than 2,000 yards. The CO orders 20 knots to complete the maneuver.

Required: 1. Initial course so as to pass astern of the guide no closer than 2,000 yards

2. Second course to reach your final destination

3. Total relative distance traveled

4. Range to the guide at CPA

5. Time to complete the maneuver

Solution: In solving problems of this type, it is necessary to first plot our initial position M_1 and our final position, M_3, (fig. 4-16). Then two tangents are constructed from these points (M_1 and M_3) to the minimum range circle. The intersection of these two tangents establishes our immediate position, M_2. This gives us two directions of relative movement (DRMs), from M_1 to M_2 for the first leg, and from M_2 to M_3 for the final leg. Consequently, we must construct two speed triangles, one to find the course for the first leg, and the other to find the course for the final leg. Symbology and annotations are used.

Answers: 1. 332.5°T

2. 266.5°T

3. 9,700 yards

4. 2,000 yards

5. 19.9 minutes

Examples of other maneuvering problems that you must become familiar with are as follows:

Collision avoidance of multiple contacts: Maneuvering to avoid multiple vessels, particularly entering and leaving busy harbors and heavily trafficked waterways.

Choice of course: A problem that has more than a single answer; where one solution has a faster completion time than the other.

Intercept: You are ordered to intercept a contact, and time and/or speed are primary factors.

Rescue destroyer station: Much like the passing-no-closer-than problem but this also includes maintaining station before and during flight operations.

UNDERWAY REPLENISHMENT

Underway replenishment (UNREP) is the term applied to all methods of transferring fuel, munitions, supplies, and personnel from one vessel to another while the ships are underway. Two general methods are used: connected and vertical. Both methods may be used simultaneously.

In the connected (CONREP) method, transfers of personnel and commodities are accomplished by means of lines and hoses rigged between ships. The vertical replenishment method, called VERTREP, uses helicopters to transfer personnel and cargo (except fuel). Transferring fuel is referred to as fueling (or refueling) at sea (FAS). Transferring cargo is called replenishment at sea (RAS).

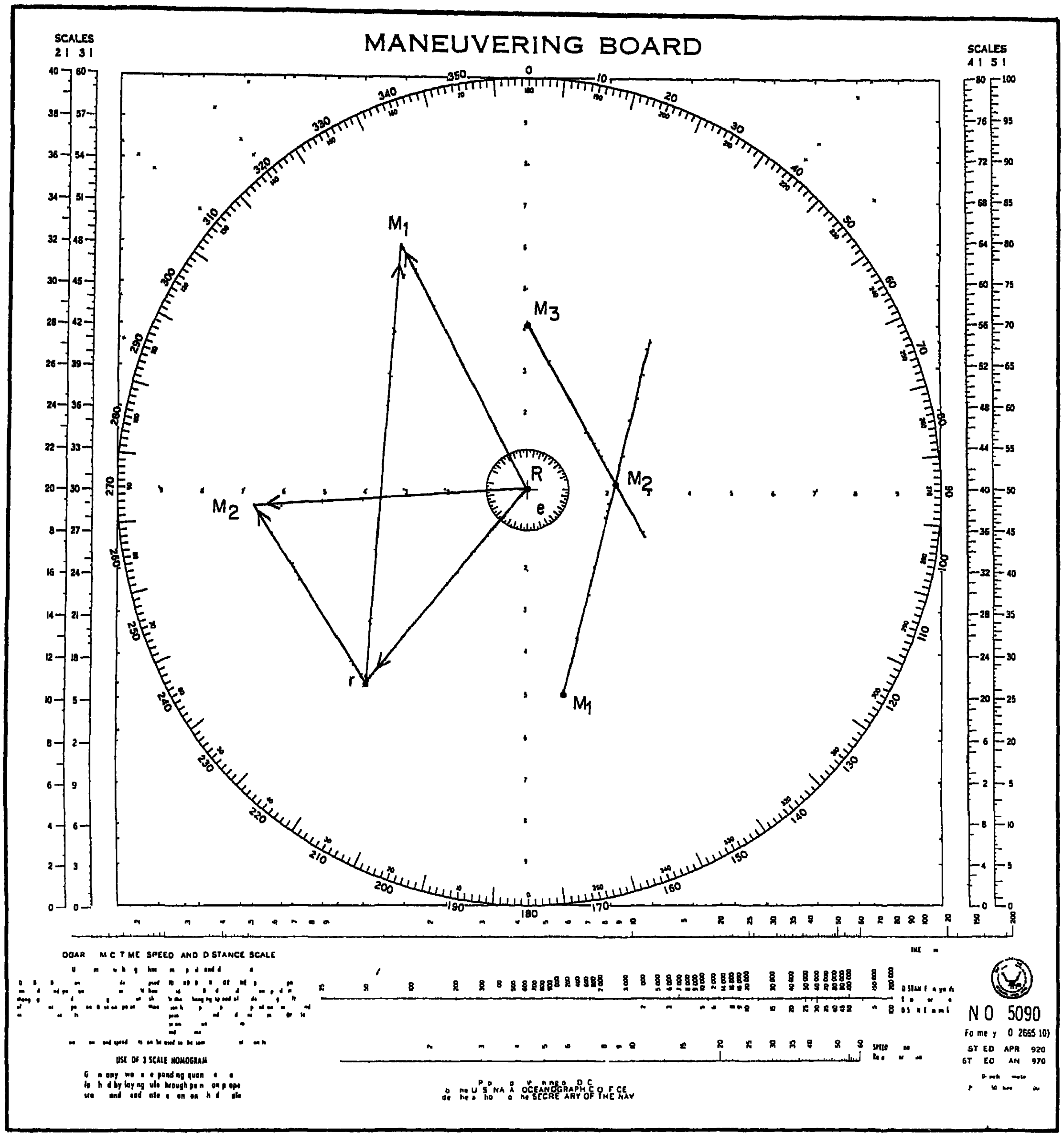

Figure 4-16.—Passing no closer than.

CONREP Procedures

The need for working at close quarters makes maneuvering during replenishment a critical operation. The distance between ships depends mainly on the type of ship being serviced and the types of rigs employed. A destroyer using a regular span-wire fueling rig, for instance, maintains a normal separation from the replenishment ship of between 60 and 100 feet; a carrier with the same equipment maintains a distance of between 100 and 140 feet.

Other considerations that bear on the best distance are sea conditions, alongside maneuverability, water depth, and speed. When ships are yawing badly, the distance should be near the maximum allowable. When water depth is less than 35 fathoms, the distance should be increased as the water becomes more shallow. Distance should also be increased as speed increases.

Pressure effects must also be taken into account. A ship underway creates a venturi effect, with areas of high pressure at the bow and stern and decreased pressure (suction) amidships. When ships are alongside each other, the effect is increased and becomes further complicated because of the intermingling of pressure areas. The effects vary with the size and configuration of the ships, the distance between ships, and speed.

Responsibilities

UNREP responsibilities are set forth in terms of shiphandling and the rigs used. Shiphandling responsibilities are those of the control ship and the approach ship, while those for the rigs are related to the delivery ship and the receiving ship. The terms are independent, but normally the control ship is the delivery ship, with the approach ship being the receiving ship.

The control ship is the guide and, as such, maintains a steady course and speed. Wind and sea conditions permitting, the best course is into the sea at a speed between 12 and 16 knots. Speeds less than 8 knots are inadvisable because of reduced rudder effect. Speeds in excess of 16 knots require greater lateral separation because of the increased venturi effect.

Maintaining Station

While alongside, maintaining station on the part of the receiving ship requires precise adjustments. Steaming too close restricts maneuverability and increases the risk of collision; too great a separation puts an undue strain on the rigs.

Because of the venturi effect, ships of the same size should remain exactly abeam. When the receiving ship is smaller, its best position lies between the bow and stern pressure areas.

Breakaway

On disengaging, during a normal breakaway, when clearing the side, the conning officer increases speed moderately (usually 3 to 5 knots) and clears ahead, directing the course outboard in small steps. Propeller wash caused by radical changes in speed and course can adversely effect steering of the control ship. A dangerous situation may develop if a ship is on the other side.

Vertical Replenishment

Vertical replenishment (VERTREP) utilizes helicopters to transport cargo and personnel from one ship to another. When used to augment alongside UNREP, VERTREP reduces the time normally required to replenish a force and the time that screening ships are off station, and enhances the replenishment of dispersed units. For small-scale replenishments, VERTREP eliminates the approach, hookup, and disconnect time required in alongside transfers.

For VERTREP, the helicopter hovers over both the transferring and the receiving ships. A relative wind of 15 to 30 knots from 30° on either bow is optimum, but other winds are acceptable, depending on various conditions. Downwind approaches and departures with an external load are dangerous and should be avoided if possible.

Because of the many publications and instructions relating to VERTREP, only a general discussion is provided in this section. Two basic publications are NWP 14, *Shipboard Replenishment At Sea*, and NWP 42, *Shipboard Helicopter Operating Procedures*.

SEARCH AND RESCUE

The operational development of search and rescue (SAR) planning and procedures resembles an evolution gained from past experiences and technological developments, coupled with an organizational structure whose design is promoting maximum efficiency and effectiveness. Because SAR may happen anywhere or any time, the SAR system is designed for flexibility and adaptability in any situation. Where land, sea, or air, or the likely combination of all three elements working together may occur, a detailed discussion is beyond the scope of this manual. Rather, a brief outline of some of the operational and administrative aspects is presented.

Administratively, the *Search And Rescue Manual*, JCS Pub 3-50, implements the national SAR plan and consolidates information needed for U.S. forces, military and civilian, to conduct SAR operations. The U.S. Coast Guard has coordinating responsibility for the promulgation of the manual and all changes thereto. The SAR manual consists of two volumes:

Volume I: National Search and Rescue Manual is composed of 13 chapters. It provides the complete overview of the SAR system and establishes organizational elements and

components, including participant responsibilities, actions, operations, and services, from origin to conclusion of an operation.

Volume II: *Planning Handbook* contains 7 chapters and provides the operational functions of SAR, including activity stages, evaluation requirements, mathematical and statical calculations, graphing, communications, and briefings.

SAR SYSTEM OVERVIEW

The SAR system is an arrangement of components activated, as needed, to efficiently and effectively assist persons or property in potential or actual distress. The SAR system components are organization, resources, communications, emergency care, and documentation. Each component defines specific actions and individual responsibilities; for example, the SAR maritime organization is divided geographically between the Atlantic SAR COORDINATOR, who is the Commander, Coast Guard Atlantic Area and the Pacific SAR COORDINATOR, who is Commander, Coast Guard Pacific. The State of Alaska is the responsibility of Commander-in-Chief, U.S. Air Force, Pacific. Overseas areas are assigned to the appropriate Unified Commanders located elsewhere in the world.

Given the implementation of SAR, designated stages define the nature of SAR assistance provided at a particular time. A mission may or may not necessarily include each and every stage, or the stages may overlap. The major stages are the following:

Awareness: Knowledge by any person or agency that an emergency situation may exist.

Initial action: Preliminary action taken to alert SAR facilities and obtain amplifying information. This stage may include evaluation and classification of the information, alerting SAR facilities, preliminary communication checks, extended communication checks, and, in urgent cases, immediate action from other stages.

Planning: The development of operational plans, including plans for search, rescue, and final delivery.

Operations: Sending search and rescue units (SRUs) to the scene, conducting searches, rescuing survivors, assisting distressed craft, providing necessary medical assistance, and delivering of casualties to medical facilities.

Mission Conclusion: Return of SRUs to a location for debriefing, refueling, replenishing, remanning, and preparation for other missions, and completion of documentation of the SAR mission by all SAR participants.

SAR MISSION ORGANIZATION

The SAR coordinator (SC) ensures operations are coordinated efficiently and at the lowest level practical. To achieve this, the coordinator is responsible for developing SAR plans, mandating mission organization, assigning responsibilities and interrelationships of participants, and developing detailed procedures for conducting SAR missions. The SAR coordinator may make SAR agreements with federal, state, local, and private agencies to provide for the maximum practicable cooperation. Figure 4-17 shows the typical SAR mission organization.

The SAR mission coordinator (SMC) is designated by the SAR coordinator to manage a specific SAR mission, and has the full operational authority of the SAR coordinator. An SMC is usually assigned for a SAR mission. While the SAR coordinator retains overall responsibility, the SMC plans and operationally coordinates and controls SAR missions from the time assigned until conclusion, prosecuting each mission with resources available.

The SMC designates an On Scene Commander (OSC) to manage a SAR mission at the scene. The OSC may be assigned from the SMC's service or

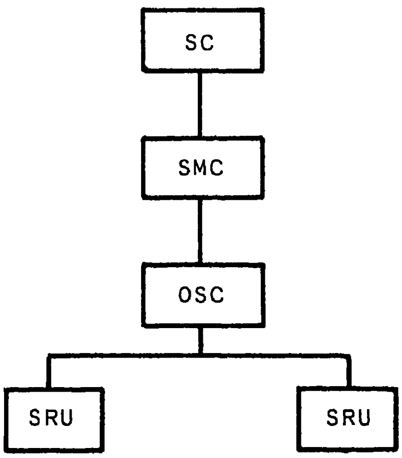

Figure 4-17.—Typical SAR mission organization.

from some other agency. Like an SMC, the OSC can be assigned by name and rank or by a particular facility. An OSC is not required for all missions, although is usually assigned if two or more SRUs are on scene. If an OSC is not designated, the first SRU on scene assumes OSC responsibilities, advising the SMC. An OSC need not be an SRU.

The search and rescue unit (SRU) is a resource performing search, rescue, or similar operations. It may have SAR as a primary duty or it may be made available for a SAR mission by a parent agency not having primary SAR duty. SRUs are normally assigned by name if a large vessel or submarine, or by type, "tail" number, or call sign if an aircraft or boat. Some SAR coordinators authorize more specific SRU abbreviations, such as search unit (SU), rescue unit (RU), and pararescue unit (PRU). SRUs should contact the OSC approximately 15 minutes before arrival, informing OSC of estimated time of arrival, operational limitations, on scene communication capability, planned search speed, and on scene endurance. If no OSC is assigned, the SRU is under the direct operational control of the SMC while on scene.

SUMMARY

Ships operations are integral to the Quartermaster rating and your professional development. When you are assigned to any command, whether sea-going or yardcraft, ANAV or POIC, you must be aware of your command's operational evolutions, operational abilities, shiphandling characteristics, and underway command structure. As a senior QM you should be completely knowledgeable of the duties and responsibilities of bridge watch officers.

Theoretical and practical shiphandling requires study and practice. Significant differences exist between single-screw or double-screw configurations, especially when combined with ship's rudders which create additional forces effecting shiphandling. These additional forces affect your ship's pivot point, turning circle, and will influence acceleration/deceleration performance. Other forces affecting practical shiphandling include wind, current, and stationary objects, such as another vessel or seawall.

Precision anchoring is a critical shiphandling evolution. There are four stages in successful anchoring, selection, plotting, execution, and postanchoring procedures. To assist the navigator, an anchor checklist must be used. Selection of an anchorage may be determined by higher authority, or the navigator, but must always be approved by the commanding officer. Plotting the anchorage requires detailed preparation of charts, including intended tracks, distance arcs, head and drop bearings to preselected navigation aids. Executing the anchorage requires close cooperation between the ship's control team on the bridge, engineering, and deck parties. Postanchoring procedures ensure the anchor is set properly and located in the correct geographic position. Repeated fixes and calculations are done to verify the anchor is well set, and within the precomputed swing and drag circles.

Common to underway operations of U.S. Navy vessels are tactical communications. The three principal tactical communication stations aboard ship are the bridge, signal bridge, and CIC. Tactical signaling methods include flashing light, flaghoist, and radiotelephone. The origin of most tactical signals is the *Allied Maritime Tactical Signal Book*, commonly referred to as the signal book. Regardless of the signaling method employed, encoded signal information is sensitive material; therefore, security procedures must be followed.

Combining shiphandling and tactical communications are tactical maneuvering and plotting underway. Two or more ships traveling together may arrange themselves in a formation. Each formation is designed for specific purposes. The two basic types of formation discussed were the line and the circular formations; detailed knowledge can be found elsewhere. Detailed use of the maneuvering board is fundamental to safe and professional seamanship, considering the inherent dangers encountered in forming and changing formations. The ability to recognize and solve complex maneuvering problems requires knowing the fundamentals of maneuvering board solutions and practicing problem solving.

The two general methods of underway replenishment are connected and vertical. Connected replenishment requires expert shiphandling during all evolutions. Vertical replenishment uses aircraft and requires that the shiphandler provide the best possible weather and sea conditions for operational efficiency and safety.

The SAR system has evolved from many sources. The current system is detailed organization, highly structured, and empowered to call upon many sources. The typical SAR mission includes the SMC, OSC, and SRUs as needed.

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CHAPTER 5

WEATHER

The tremendous horsepower of the modern ship makes it a rare occurrence for a ship to be lost at sea because of adverse weather. But even the largest ships have much to fear when engulfed in a severe storm. A severe North Atlantic gale, for example, is capable of straining rigging, springing seams, and bending the topside equipment on a ship the size of an 84,000-ton aircraft carrier. Winds of over 100 knots and waves 60 feet and higher are respected by the hardiest seamen on the largest ships. Whenever practical, the prudent mariner always maneuvers to stay clear of storms.

Before the days of radio communication and the Weather Bureau, seafarers became weather-wise through experience. Today, a ship at sea is regularly advised by radio concerning weather conditions in her vicinity. Nevertheless, it still is possible for a hurricane or typhoon to originate suddenly, without any warning except a sharply falling barometer and other local indications described in this chapter. A first-rate navigator should be able, by means of certain characteristic signs, to recognize what weather disturbance is coming. He or she should know how to tell what kind of a storm it is, how bad it may be and—most important of all—how to maneuver so as to avoid its full impact.

The ship's Quartermaster is not directly concerned with maneuvering the ship; but, as assistant navigator, he or she should know enough about the laws of storms to be able to assist with intelligent observation of the weather and to know the oceanographic and meteorological support and services that are provided by the Naval Oceanography Command.

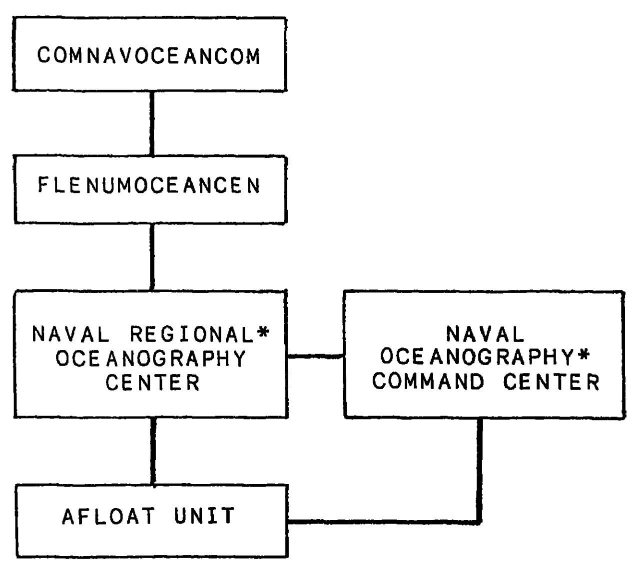
NAVAL OCEANOGRAPHY COMMAND

Commander, Naval Oceanography Command (NAVOCEANCOM) is the responsible U.S. Navy agency for meteorological and oceanographic support and services. NAVOCEANCOM's mission is to ensure that Department of the Navy oceanographic and meteorological requirements and Department of Defense oceanographic requirements are met.

Because of the many and varied operations and tasks required of today's Navy, NAVOCEANCOM has implemented the Naval Oceanographic and Meteorological Support System (NOMSS) to meet those needs. NOMSS is a collective title that includes all Navy and Marine Corps units that contribute oceanographic, meteorological, or hydrographic observations or services; the activities and detachments assigned to NAVOCEANCOM; and a very limited number of other oceanographically and meteorologically oriented activities.

NAVOCEANCOM ACTIVITIES

Shore (field) activities, detachments, and units assigned to NAVOCEANCOM are organized to collectively provide global fleet support. Because the total NAVOCEANCOM organization and functions are beyond the scope of this manual, figure 5-1 illustrates a typical organizational flow



*Responsibility determined by geographic location of afloat unit

Figure 5-1.—Organizational flow chart to an afloat unit.

chart between an afloat unit and NAVOCEANCOM. A brief discussion of each level follows:

- Fleet Numerical Oceanography Center: The Fleet Numerical Oceanography Center (FLENUMOCEANCEN) is the master computer center for NOMSS and the hub of the Naval Enviromental Data Network. FLENUMOCEANCEN is linked with the data collecting and distribution networks of the U.S. Air Force, the National Oceanic and Atmospheric Administration, and the World Meteorological Organization. From these data, basic and applied numerical (computer) products are generated by the FLENUMOCEANCEN for use by the NOMSS in producing specific fleet support products and services.

- Naval Regional Oceanography Center: Three Naval Oceanography Centers have been established to provide coverage. They are located at Pearl Harbor, Hawaii, Norfolk, Virginia, and Suitland, Maryland. The areas of responsibility are the Pacific and Indian Oceans; Atlantic Ocean and Mediterranean Sea; and the Arctic and Antarctic areas, respectively. The centers use and add to the basic and applied numerical products from FLENUMOCEANCEN to provide fleet environmental broadcasts and tailor support in response to specific requests by the operating forces.

- Naval Oceanography Command Centers: There are two Naval Oceanography Command Centers, located in Guam and in Rota, Spain. The center in Guam assists in the provision of environmental services in the western Pacific and Indian Ocean areas, and Rota, Spain, assists in the Mediterranean Sea. A seeming redundancy occurs between the Regional Centers and the Command Centers because they both utilize the basic and applied numerical products from the FLENUMOCEANCEN to provide services and support to the fleet. This redundancy is purposely implemented to adequately and properly provide services and support to these two areas because they are heavily traveled, and typically contain significant numbers of operationally deployed naval units.

- Participating Units: Ships, aircraft squadrons, and some shore activities to which no geophysical personnel are assigned are also elements of NOMSS in that they directly contribute environmental observations.

MISSION AND FUNCTION

The mission of NAVOCEANCOM, previously mentioned, is oceanographic and meteorological support and services. NOMSS has been implemented to meet mission goals. Figure 5-1 depicts the levels of responsibilities; figure 5-2 depicts the areas of cognizant NAVOCEANCOM responsibilities and those of participating units

Essentially, geographic location determines the environmental reporting and responding responsibilities for NAVOCEANCOM activities and participating units. Refer to figure 5-2 when reading the following example: Your vessel is proceeding from the Atlantic Ocean into the Mediterranean Sea. Your Atlantic Ocean environmental information came from the Regional Center in Norfolk, Virginia, likewise, your weather observations and other requests were sent to Norfolk. Upon your entering the Mediterranean Sea area, information will now originate from the Command Center in Rota, Spain, and your reporting observations are sent to Rota.

ENVIRONMENTAL SUPPORT SERVICES

In general, environmental support routinely provided to operating forces is tailored in accordance with the requirements of fleet and force commanders. The services provided consist of oceanographic and meteorological information and forecasts for climatological information, plus, operational and tactical applications.

The *U.S. Navy Oceanographic & Meteorological Support System Manual*, NAVOCEANCOMINST 3140.1, describes specific and general services and support available from NAVOCEANCOM, along with requesting procedures. Obviously, a variety of factors are used to determine the degree and type of support (for example, class of ship, weapon and sensor capabilities, seasonality); a brief discussion follows.

MISSION REQUIREMENTS

Mission requirements are a prime determinant of the nature of environmental support. Considering that mission requirements are very broad and encompass a great deal, the departure, transiting, and ultimately, final destination of your vessel, along with operational concerns and requirements, require close communications between yourself and NAVOCEANCOM.

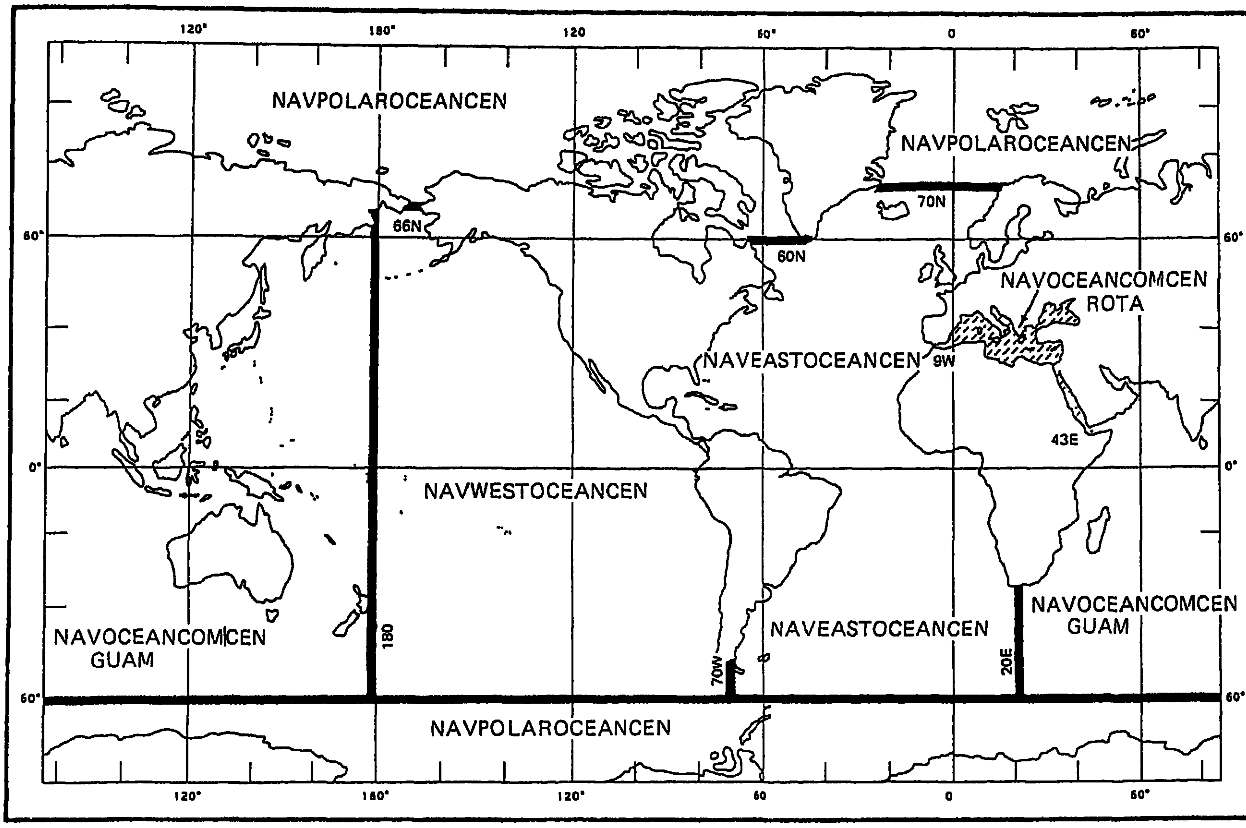


Figure 5-2.—Areas of responsibility.

Forces afloat receive support from Regional Oceanography Centers and Oceanography Command Centers. Refer to figure 5-2 for areas of responsibility. Requests for environmental support should be addressed to the appropriate NAVOCEANCOM activity. Whether using environmental Address Indicator Groups (AIGs) or the *OPERATIONAL REPORTS PUBLICATION*, Naval Warfare Publication 7(A), to request services, as a senior QM you must know the correct procedures and the cognizant activity responsible.

Routine Support Services

Most support routinely required by fleet units is available on a regularly scheduled basis via Navy communication channels. Examples are Wind Warnings, Tropical Cyclone Forecasts and Warnings, High Sea Warnings, Ice Conditions, Fleet Operating Area Forecasts, and Local Severe Weather.

Receipt of these communiques may be through standard message traffic, synoptic forecasts, facsimile charts, or voice broadcast via radiotelephone. Interpretation and applicability are discussed later in the chapter.

Specialized Support

Specific operations require specialized support services; for example, anti-submarine operations require acoustic information, and arctic operations require ice forecasts. Requests should be forwarded in accordance with *COMNAVOCEANCOM Tactical Support Products Manual (U)*, NAVOCEANCOM C3160.4(A) Volume II.

Requests should include relevant operational information, such as ship's schedule, route, intended movement, and other special considerations. Common examples of specialized support are Optimum Track Ship Routing (OTSR), Route Weather Forecasts (WEAX), Mobile Environmental Team (MET) Services, Search and Rescue (SAR) Planning Guidance, and Amphibious Operations Forecasts.

The supporting NAVOCEANCOM activity normally responds via standard message traffic

and may require the requestor to increase normal services, that is, increased and/or limited observations.

TYPES OF SERVICES

NAVOCEANCOM provides a considerable amount of services, and many of those are beyond the scope of this manual. Therefore, the following is only a partial listing with a brief discussion.

- Wind Warnings: Warnings of winds are categorized by location of storm origin and wind speed(s). Location or locale refers to the storm origin and the NAVOCEANCOM activity who reports the warning(s). *Storm origin* is an inclusive term. It means storms are reported via wind warnings using the following parameters: winds associated with extra-tropical weather systems or tropical systems, and cyclonic circulations of tropical origin.

Examples of wind warnings are small craft advisories, and gale and storm warnings. A tropical depression, tropical storm, and hurricane or typhoon are examples of severe winds.

- High-Sea Warnings: These warnings are issued every 12 hours whenever actual or forecast wave heights in an ocean area of the Northern Hemisphere equal or exceed 12 feet.

- Local Severe-Storm Warnings: These are forecasts of weather phenomena that might endanger ships, aircraft, or shore stations. Some examples are thunderstorms, squalls, tornadoes, and hail.

- WEAX: A service usually requested on a ship's MOVREP as a line item, the WEAX is designed to provide routine and special weather forecasts along a ship's intended route. *Operational Reports*, NWP 7(A), is the cognizant MOVREP publication.

- OTSR: OTSR is an advisory service designed to provide savings of time and/or fuel via route recommendations and adjustments. Additionally, route surveillance also reduces the risk of damage from storms, high seas, and sea ice.

One particular requirement imposed is that your voyage must be 1,500 nautical miles or longer in unrestricted waters to feasibly allow for route changes and provide significant savings. Some restricted waters have route surveillance provided, while others do not; for example, the Caribbean Sea and U.S. coastal areas are covered, but the Mediterranean area is not. Strong ocean currents are taken into effect and used or minimized whenever possible.

Requesting OTSR is either by letter or message to the appropriate OCEANCEN, and includes FLENUMOCEANCOM as an information addee. Among the information that must be provided as part of the request is point of departure, classification of movement, ship and cargo characteristics, destination, estimated time of arrival, cruising speed, and maximum acceptable speed.

- Other Warnings: Additional information and weather warnings are provided by *Warnings and Conditions of Readiness Concerning Hazardous or Destructive Weather Phenomena*, OPNAVINST 3140.24; various directives of the OPNAV 3140- and 5400-series; SOPA instructions; and pertinent operations orders.

WEATHER CHARTS

The prediction of weather is based upon an understanding of weather processes and observations of present conditions. Thus, one learns that when there is a certain sequence of cloud types, rain usually follows within a certain period. If the sky is cloudless, more heat will be received from the sun by day, and more heat radiated outward from the warm Earth by night, than if the sky were overcast. If the wind is in such a direction that warm, moist air will be transported over a colder surface, fog can be expected. A falling barometer indicates the approach of a "low," probably accompanied by stormy weather Thus, before meteorology passed from an art to a science, many individuals learned to interpret certain atmospheric phenomena and to make reasonably accurate weather forecasts for short periods.

Ordinarily, weather maps for surface observations are prepared every 6 (sometimes 3) hours. In addition, synoptic charts for selected heights are prepared every 12 (sometimes 6) hours. Knowledge of conditions aloft is of value in establishing the three-dimensional structure and motion of the atmosphere as input to the forecast.

With the advent of the digital computer, highly sophisticated numerical models have been developed to analyze and forecast weather patterns. The civil and military weather centers

prepare and disseminate vast numbers of weather charts (analyses and forecasts) daily to assist local forecasters in providing users with accurate, predicted weather parameters. It must be remembered that in any area, the accuracy of forecasted parameters decreases with the length of the forecast period. Thus, a 12-hour forecast is likely to be more reliable than a 24-hour forecast. Long-term forecasts (for 2 weeks or a month in advance) are limited to general statements. For example, a prediction is made as to which areas will have temperatures above or below normal and how precipitation will compare with normal, but no attempt is made to state that rainfall will occur at a certain time and place.

Forecasts are issued for various areas. The national meteorological services of most maritime nations, including the United States, issue forecasts for ocean areas and warnings of the approach of storms. The efforts of the various nations are coordinated through the World Meteorological Organization. Therefore, your task as ANAV or QM LCPO will be to interpret synoptic weather charts and bulletins provided by the various sources.

WEATHER FACSIMILE CHARTS

The process for transmitting pictorial and graphic information by wire, radio, or satellite and reproducing it in its original form at the receiving station is called "facsimile."

The use of facsimile equipment eliminates the need, in many instances, for the navigator to construct his or her own weather chart. See figure 5-3.

Synoptic weather charts, routinely updated, are available to ships at sea continuously using the radio facsimile process. These facsimile charts display a complete area weather analysis. They normally use the standard symbolic form of synoptic code.

The *Facsimile Products Guide* is produced by the Naval Eastern Oceanography Center, Norfolk, Virginia, and the Naval Western Oceanography Command, Pearl Harbor, Hawaii. It contains the following information:

1. Radio facsimile broadcast frequencies
2. Radio facsimile broadcast schedules
3. A listing of the radio facsimile products available from the Naval Oceanography Centers

This publication must be available when radio facsimile gear is on board.

WEATHER CHART SYMBOLS

Standard codes used to send and receive weather data at sea have been developed and refined over many years. These codes were discussed thoroughly in the *Quartermaster 3* TRAMAN and should be reviewed. In this section, we will help you learn to convert these standard synoptic weather codes to standard weather symbols, which are plotted on a weather chart. We will also help you to interpret preplotted weather charts and radio facsimiles.

Weather data received in code from a land station or a ship at sea are plotted on the chart at the symbol representing the location of the station or ship. Thus, you have available at a glance a complete and readily understandable graphical representation.

The following standard procedures are used to enter data (called the station model) at any station or ship on the chart:

Wind direction is indicated by an arrow pointing the way the wind is blowing. That is, the arrow points to the west if the wind is an east wind. Each full barb on the wind arrow represents 10 knots of mean velocity; each half-barb represents 5 knots of mean velocity. For an exact breakdown of barbs on the wind arrows in miles per hour and in Beaufort force, see table 5-1.

NOTE

The lowest wind-speed increment plotted on a weather chart is 5 knots, indicated by the half-barb symbol. For example, a 3-knot wind would be plotted as a 5-knot wind, using the half-barb symbol; an 18-knot wind would be plotted as a 20-knot wind using two full barbs.

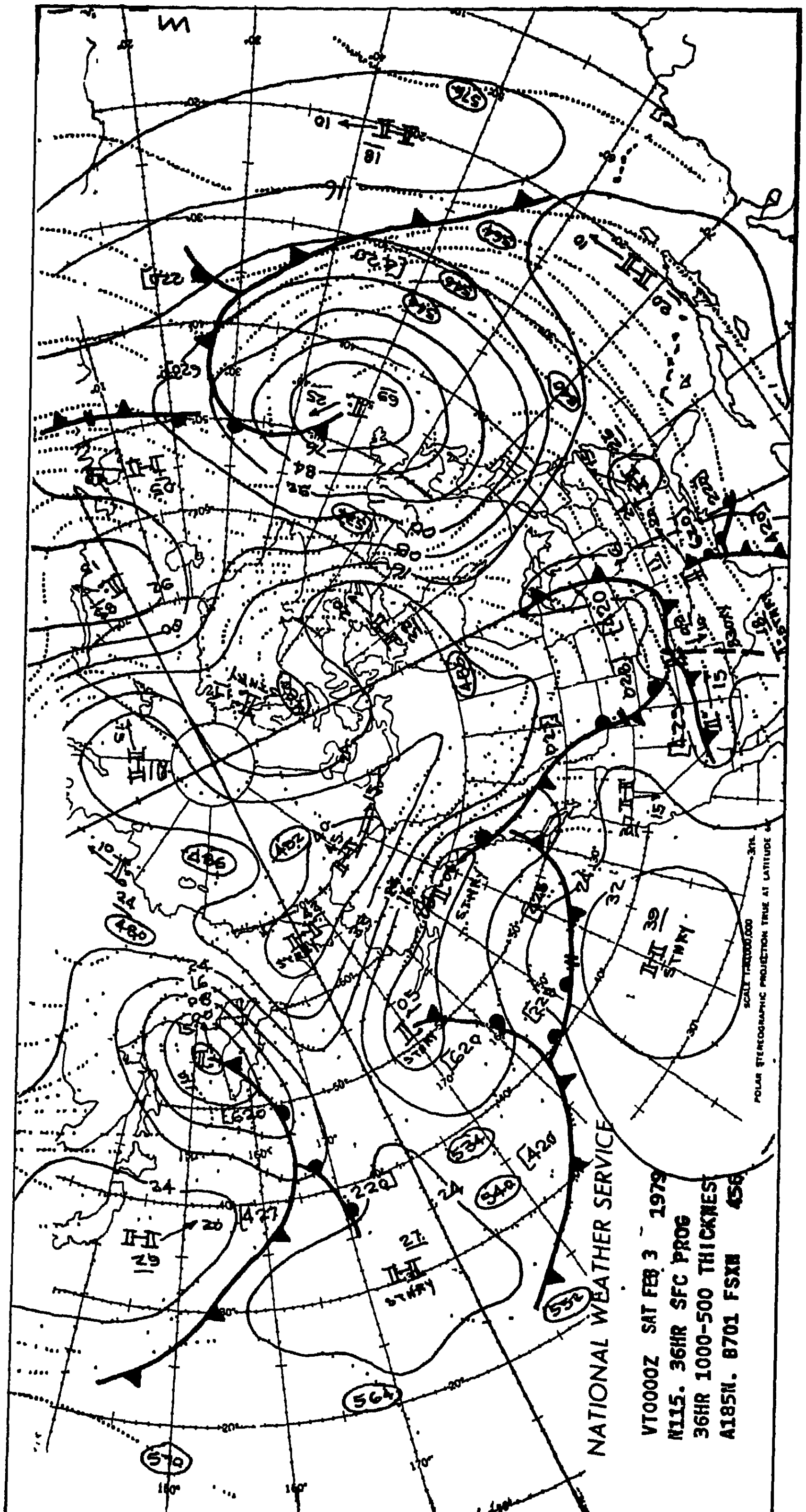


Figure 5-3.—Surface weather analysis radio facsimile chart.

Table 5-1.—Beaufort Wind Scale and Wind Symbols used on Weather Charts

Beaufort Number	*Knots*	*Miles Per Hour*	*Description*	*Effect at sea*	*Wind Symbols on Weather Charts*
0	0-0.9	0-0.9	Calm	Sea like a mirror.	Calm
1	1-3	1.3	Light air	Scale-like ripples form, but without foam crests.	Almost Calm
2	4-6	4-7	Light breeze	Small wavelets, short but more pronounced. Crest have a glassy appearance and do not break.	5 Knots
3	7-10	8-12	Gentle breeze	Large wavelets. Crests begin to break. Foam has glassy appearance. Perhaps scattered white horses.	10 Knots
4	11-16	13-18	Moderate breeze	Small waves, becoming longer. Fairly frequent white horses.	15 Knots
5	17-21	19-24	Fresh breeze	Moderate waves, taking a more pronounced long form. Many white horses are formed. Chance of some spray.	20 Knots
6	22-27	25-31	Strong breeze	Large waves begin to form. White foam crests are more extensive everywhere. Some spray.	25 Knots
7	28-33	32-38	Moderate gale	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind. Spindrift begins	30 Knots
8	34-40	39-46	Fresh gale	Moderately high waves of greater length. Edges of crests break into spindrift. Foam is blown in well-marked streaks along the direction of the wind.	35 Knots
9	41-47	47-54	Strong gale	High waves. Dense streaks of foam along the direction of the wind. Sea begins to roll. Spray may affect visibility.	45 Knots
10	48-55	55-63	Whole gale and/or Storm	Very high waves with long overhanging crests The resulting foam is great patches is blown in dense white streaks along the direction of the wind. On the whole, the surface of the sea takes a white appearance The rolling of the sea becomes heavy and shocklike. Visibility is affected.	50 Knots
11	56-63	64-73	Storm and/or Violent Storm	Exceptionally high waves. Small- and medium-sized vessels might for a long time be lost to view behind the waves. The sea is completely covered with long white patches of foam lying along the direction of the wind. Everywhere, the edges of the wave crests are blown into froth. Visibility seriously affected.	60 Knots
12	64 or higher	74 or higher	Hurricane & Typhoon	The air is filled with foam and spray. Sea is completely white with driving spray. Visibility is very seriously affected.	75 Knots

Code Number	CL	Description (Abridged From W M O. Code)
1		Cu of fair weather, little vertical development and seemingly flattened
2		Cu of considerable development, generally towering with or without other Cu or Sc bases all at same level
3		Cb with tops lacking clear-cut outlines, but distinctly not cirriform or anvil-shaped with or without Cu, Sc, or St
4		Sc formed by spreading out of Cu, Cu often present also
5		Sc not formed by spreading out of Cu
6		St or Fs or both, but no Fs of bad weather
7		Fs and/or Fc of bad weather (scud)
8		Cu and Sc (not formed by spreading out of Cu) with bases at different levels
9		Cb having a clearly fibrous (cirriform) top often anvil-shaped with or without Cu Sc St, or scud

Code Number	CM	Description (Abridged From W M O Code)
1		Thin As (most of cloud layer semitransparent)
2		Thick As, greater part sufficiently dense to hide sun (or moon), or Ns
3		Thin Ac, mostly semi-transparent; cloud elements not changing much and at a single level.
4		Thin Ac in patches, cloud elements continually changing and/or occurring at more than one level
5		Thin Ac in bands or in a layer gradually spreading over sky and usually thickening as a whole.
6		Ac formed by the spreading out of Cu
7		Double-layered Ac, or a thick layer of Ac, not increasing, or Ac with As and/or Ns
8		Ac in the form of Cu-shaped tufts or Ac with turrets
9		Ac of a chaotic sky, usually at different levels, patches of dense Ci are usually present also

Code Number	CH	Description (Abridged From W M O Code)
1		Filaments of Ci, or "mares tails," scattered and not increasing
2		Dense Ci in patches or twisted sheaves, usually not increasing, sometimes like remains of Cb, or towers or tufts
3		Dense Ci often anvil-shaped, derived from or associated with Cb
4		Ci, often hook-shaped, gradually spreading over the sky and usually thickening as a whole
5		Ci and Cs often in converging bands, or Cs alone, generally overspreading and growing denser, the continuous layer not reaching 45° altitude
6		Ci and Cs, often in converging bands, or Cs alone, generally overspreading and growing denser, the continuous layer exceeding 45° altitude
7		Veil of Cs covering the entire sky
8		Cs not increasing and not covering entire sky
9		Cc alone or Cc with some Ci or Cs, but the Cc being the main cirriform cloud

Cloud Abbreviation
St or Fs-Stratus or Fractostratus
Ci-Cirrus
Cs-Cirrostratus
Cc-Cirrocumulus
Ac-Altocumulus
As-Altostratus
Sc-Stratocumulus
Ns-Nimbostratus
Cu or Fc-Cumulus or Fractocumulus
Cb-Cumulonimbus

Figure 5-4.—Cloud types.

Cloud types, cloud height, and sky coverage are denoted by the symbols contained in figures 5-4, 5-5, and 5-6, respectively.

Temperature is given in degrees Fahrenheit and/or in degrees Celsius.

Atmospheric pressure is represented to the tenth of a millibar, with only the last three figures plotted.

Barometric pressure tendency for any change over the previous 3 hours is also indicated on the station model, and directly below this symbol is the sign for past weather. See figure 5-7.

Dew-point temperature is designated in degrees Fahrenheit and in degrees Celsius.

Present weather is shown by an appropriate symbol on the station model (fig. 5-8). Directly to the west of this symbol is the visibility, in miles.

N	N_h	Sky Coverage
○	0	No clouds
	1	Less than one-tenth or one-tenth
	2	Two and three-tenths
	3	Four-tenths
	4	Five-tenths
	5	Six-tenths
	6	Seven and eight-tenths
	7	Nine-tenths or overcast with openings
●	8	Completely overcast
⊗	9	Sky obscured

Figure 5-6.—Sky coverage.

h	Height in Feet (Rounded Off)	Height in Meters (Approximate)
0	0 - 149	0 - 49
1	150 - 299	50 - 99
2	300 - 599	100 - 199
3	600 - 999	200 - 299
4	1,000 - 1,999	300 - 599
5	2,000 - 3,499	600 - 999
6	3,500 - 4 999	1,000 - 1,499
7	5,000 - 6,499	1,500 - 1,999
8	6,500 - 7,999	2,000 - 2,499
9	At or above 8,000, or no clouds	At or above 2,500, or no clouds

Figure 5-5.—Cloud height.

Code Number	W	Past Weather
0		Clear or few clouds (Not Plotted)
1		Partly cloudy (scattered) or variable sky (Not Plotted)
2		Cloudy (broken) or overcast (Not Plotted)
3	S/+	Sandstorm or duststorm, or drifting or blowing snow
4	≡	Fog, or smoke, or thick dust haze
5	,	Drizzle
6	•	Rain
7	*	Snow, or rain and snow mixed, or ice pellets (sleet)
8	∇	Shower(s)
9		Thunderstorm, with or without precipitation

Figure 5-7.—Past weather.

[redacted]

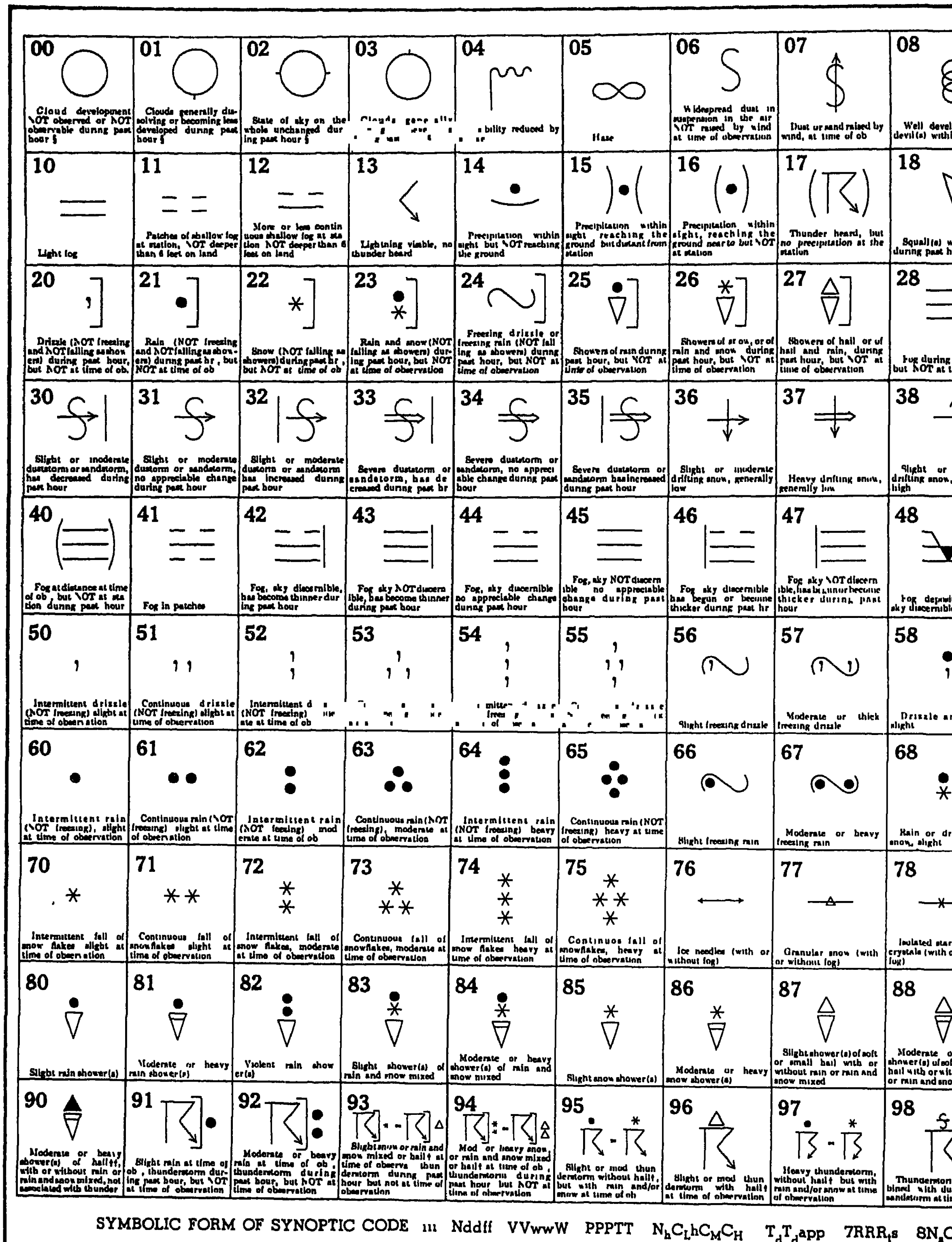


Figure 5-8.—Weather code figures and symbols, with their meanings.

09 Dustorm or sandstorm within sight of or at station during past hour	0 No Sc, St, Cu, or Cb clouds	0 No Ac, As or Ns clouds	0 No Ci, Cc, or Cs clouds	0 Ci	0 Cloud covering ½ or less of sky throughout the period	0 No clouds	0 Rising then falling Now higher than, or the same as, 3 hours ago
19 Funnel cloud(s) within sight during past hour	1 Ragged Cu, other than bad weather, or Cu with little vertical development and seemingly flattened, or both	1 As, the greatest part of which is semitransparent through which the sun or moon may be faintly visible as through ground glass	1 Filaments, strands, or hooks of Ci, not increasing	1 Cc	1 Cloud covering more than ½ of sky during part of period and covering ½ or less during part of period	1 One tenth or less, but not zero	1 Rising, then steady, or rising, then rising more slowly Now higher than 3 hours ago
29 Thunderstorm (w [illegible]	2 Cu of considerable [illegible]	2 As [illegible]	2 Dense Ci in patches or [illegible] sheaves, usually [illegible]ncreasing or Ci towers or battle[illegible] or resembling [illegible]uliform tufts	2 Cs	2 Cloud covering more than ½ of sky throughout the period	2 Two- or three-tenths	2 Rising (steady or unsteadily) Now higher than 3 hours ago
39 Heavy drifting snow, generally high	3 Cb with tops lacking clear cut outlines, but are clearly not fibrous, cirriform, or anvil shaped, Cu, Sc, or St may be present	3 Ac (most of layer is semitransparent) other than crenelated or in cumuliform tufts, cloud elements change but slowly with all bases at a single level	3 Ci often anvil shaped derived from or associated with Cb	3 Ac	3 Sandstorm or duststorm, or drifting or blowing snow	3 Four tenths	3 Falling or steady, then rising, or rising then rising more rapidly Now higher than 3 hours ago
49 Fog, depositing rime, sky NOT discernible	4 Sc formed by spreading out of Cu, Cu may be present also	4 Patches of semitransparent Ac which are at one or more levels cloud elements are continuously changing	4 Ci hook shaped and/or filaments spreading over the sky and generally becoming denser as a whole	4 As	4 Fog, or thick haze	4 Five-tenths	4 Steady Same as 3 hours ago
59 Drizzle and rain moderate or heavy	5 Sc not formed by spreading out of Cu	5 Semitransparent Ac in bands or Ac in one more or less continuous layer gradually spreading over sky and usually thickening as a whole the layer may be opaque or a double sheet	5 Ci often in converging bands and Cs or Cs alone but increasing and growing denser as a whole the continuous veil not exceeding 45° above horizon	5 Ns	5 Drizzle	5 Six tenths	5 Falling, then rising Now lower than, or the same as 3 hours ago
69 Rain or drizzle [illegible] snow mod'te or hea[illegible]	6 St in a more or less [illegible]	6 [illegible] the	6 Ci often in converging bands, and Cs or Cs alone but increasing and growing denser as a whole, the continuous veil exceeds 45° above horizon but sky not totally covered	6 Sc	6 Rain	6 Seven or eight tenths	6 Falling then steady or falling, then falling more slowly Now lower than 3 hours ago
79 Ice pellets (sleet U S definition)	7 Fs and/or Fc of bad weather (scud) usually under As and Ns	7 Double layered Ac or an opaque layer of Ac not increasing over the sky or Ac coexisting with As or Ns or with both	7 Veil of Cs completely covering the sky	7 St	7 Snow or rain and snow mixed, or ice pellets (sleet)	7 Nine tenths or more but not ten tenths	7 Falling (steadily or unsteadily) Now lower than 3 hours ago
89 Slight shower(s) of hail†† with or without rain or rain and snow mixed not associated with thunder	8 Cu and Sc (not formed by spreading out of Cu) base of Cu at a different level than base of Sc	8 Ac with sprouts in the form of small towers or battlements or Ac having the appearance of cumuliform tufts	8 Cs not increasing and not completely covering the sky	8 Cu	8 Shower(s)	8 Ten tenths	8 Steady or rising, then falling, or falling then falling more rapidly Now lower than 3 hours ago
99 Heavy thunderstorm with hail†† at time of ob	9 Cb having a clearly fibrous (cirriform) top often anvil shaped with or without Cu Sc St, or scud	9 Ac generally at several layers in a chaotic sky dense Cirrus is usually present	9 Cc alone or Cc accompanied by Ci and/or Cs but Cc is the predominant cirriform cloud	9 Cb	9 Thunderstorm with or without precipitation	9 Sky obscured, or cloud amount cannot be estimated	9 Indicator figure Regionally agreed elements and NOT 'pp' are reported by the next two code figures

$9S_pS_ps_ps_p$ $1d_wd_wP_wH_w$ $2h_{85}h_{85}h_{85}a_3$ $3R_{24}R_{24}R_{24}R_{24}$ $4T_xT_xT_nT_n$ (Additional Plain Language Data)

Figure 5-8.—Weather code figures and symbols, with their meanings—Continued.

Figure 5-9 shows you how to enter data from weather broadcasts on a weather chart. An explanation of the symbols and map entries also appears in the illustration. Complete descriptions of all weather symbols used in the construction of a station model are included in figures 5-4 through 5-9.

Figure 5-10 shows standard symbols used on radiofacsimile weather charts. These symbols are straightforward for ease of use.

Various fleet forces may use "special" synoptic charts or weather codes as the fleet or force commander wishes. Instructions for interpreting these charts or codes must accompany them, or the message must reference the manual containing the instructions.

When all available synoptic weather reports have been entered on the weather chart, it is ready for analyzing.

Isobars

Isobars are lines of equal pressure. In this respect, isobars are similar to fathom curves, which are lines of equal depth. Isobars are also much like contour lines, because the closer they are together, the steeper the barometric slope over that particular area. This latter aspect makes isobars especially valuable in determining surface wind speed. Isobars are drawn on surface weather charts to outline areas of high and low sea-level pressure.

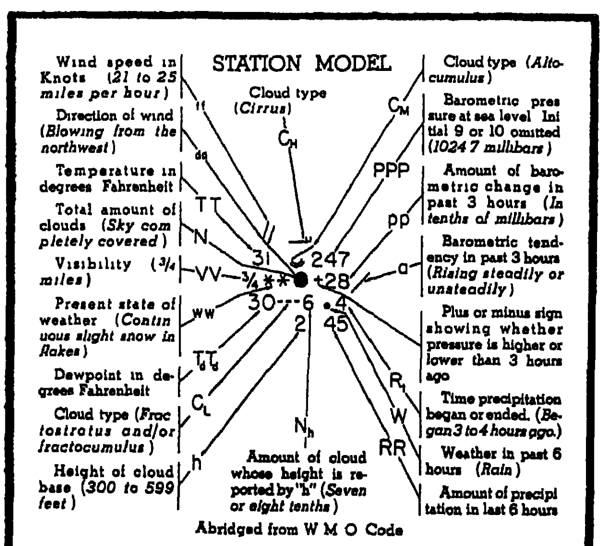


Figure 5-9.—A weather station weather-chart model.

Isobaric Analysis

Before isobaric information on a weather chart can be analyzed, atmospheric data must be converted to isobars (hand-drawn contours).

It is not as easy as it appears to accurately draw isobars from the reports on atmospheric pressure. If the isobars are drawn incorrectly, predictions based on their analysis will be wrong. The first principle to remember is that the isobar must form a closed curve. In other words, your pencil must eventually work back to its starting point, provided the chart is on a sufficiently small scale. If it isn't, your line must wind up in the margin. If you find your line crossing another or stopping in the middle of the chart, you have done something wrong.

Isobars are drawn in 2-millibar (mb) intervals from the equator to 25° latitude, and in 4-mb intervals from 25° latitude poleward, with 1,000 mb as the base value. To determine the exact equator and 25°N and 25°S, use 1,000 mb as a base value and proceed toward both the increasing and decreasing values in increments of 2 mb. Use table 5-2 to convert inches of mercury to millibars and vice-versa.

Isobars should be drawn so that they agree not only with the pressure but also with the wind. The distance between isobars should agree with the reported wind speed. The stronger the wind, the closer the isobars. It must also be kept in mind that winds blow across isobars at a slight angle, inward toward a center of low pressure and outward from a center of high pressure. If the terrain is smooth, the angle is small; however, the rougher the terrain, the greater the angle. Winds over ocean areas blow across the isobars at an angle of 10° to 20°; with winds over very rough land, the angle may be as much as 40°.

NOTE

In the Northern Hemisphere, if the isobar is traced into the wind, it must be kept to the right of all points where pressure is higher than its value. If it is traced with the wind, it must be kept to the left of all such points.

In general, this concept holds over sea areas, but does not always apply over the land. The reason is that wind directions observed locally at land stations do not always conform to the general pattern of large-scale atmospheric motion stated

INTERPRETATION OF RADIOFACSIMILE WEATHER CHARTS

The radiofacsimile weather charts listed in section 3 are surface charts. Most of the analyses and prognoses will be similar to hand-plotted surface weather charts However, some surface charts represent an attempt to present the weather pattern in a more descriptive way; in terms of the weather recognized by the mariner The low-latitude charts transmitted by Radio NMC, San Francisco are a good example of this trend On these charts, the sea-level pressure pattern has been replaced with streamlines depicting the direction of the wind. There is notation of wind speed and areas of significant weather and high waves Centers of high and low pressure and frontal systems are also shown.

The following table explains the symbols and notation commonly used on radiofacsimile weather charts

*SYMBOLS FOR FRONTS, CONVERGENCE LINES, ETC	
COLD FRONT AT THE SURFACE	QUASI STATIONARY FRONT AT THE SURFACE
COLD FRONT ABOVE THE SURFACE	QUASI-STATIONARY FRONT ABOVE THE SURFACE
WARM FRONT AT THE SURFACE	CONVERGENCE LINE
WARM FRONT ABOVE THE SURFACE	INTER-TROPICAL CONVERGENCE ZONE
OCCLUDED FRONT AT THE SURFACE	
OCCLUDED FRONT ABOVE THE SURFACE	NOTE THE SEPARATION OF THE TWO LINES GIVES A QUALITATIVE REPRESENTATION OF THE WIDTH OF THE ZONE, THE HATCHED LINES MAY BE ADDED TO INDICATE AREAS OF ACTIVITY

AN ARROW INDICATES THE EXPECTED DIRECTION OF MOVEMENT OF A FRONT AND NEXT TO THE ARROW THE EXPECTED SPEED OF MOVEMENT (IN KNOTS) IS GIVEN

SYMBOLS FOR SIGNIFICANT WEATHER	SYMBOLS FOR TYPES OF AIR MASSES	
THUNDERSTORM	cA	ARCTIC, CONTINENTAL
TROPICAL REVOLVING STORM (HURRICANE/TYPHOON, ETC)	mA	ARCTIC, MARITIME
SEVERE LINE SQUALL	cP	POLAR, CONTINENTAL
HAIL	mP	POLAR, MARITIME
WIDESPREAD SANDSTORM OR DUSTSTORM	cT	TROPICAL, CONTINENTAL
FREEZING RAIN	mT	TROPICAL, MARITIME
• RAIN	E	EQUATORIAL
* SNOW	S	SUPERIOR

THE ABOVE SYMBOLS MAY BE FOLLOWED BY A SMALL LETTER "k" OR "w" THESE LETTERS INDICATE THE FOLLOWING

k THE AIR MASS IS COLDER THAN THE SURFACE OVER WHICH IT IS PASSING

w THE AIR MASS IS WARMER THAN THE SURFACE OVER WHICH IT IS PASSING

OTHER SYMBOLS AND CONVENTIONS

BOUNDARY OF AREAS OF SIGNIFICANT WEATHER

ABBREVIATIONS	
CLD —CLOUD	LYR —LAYER OR LAYERED
FRQ —FREQUENT	OCNL —OCCASIONAL OR OCCASIONALLY
GRADU —GRADUAL OR GRADUALLY	SCT —SCATTERED

HIGH- AND LOW-PRESSURE CENTERS ARE REPRESENTED BY H AND L RESPECTIVELY, THE POSITION AT THE SURFACE OF THE POINT OF HIGHEST OR LOWEST PRESSURE BEING INDICATED BY + FOLLOWED BY THE VALUE OF THE MSL PRESSURE IN MILLIBARS AN ARROW INDICATES THE EXPECTED DIRECTION OF MOVEMENT OF THE PRESSURE CENTER AND THE EXPECTED SPEED OF MOVEMENT (IN KNOTS) THE VALUE OF EACH ISOBAR (LINE OF EQUAL ATMOSPHERIC PRESSURE) IS LABELED

Figure 5-10.—Interpretation of radio facsimile weather charts.

Table 5-2.—Conversion Table, Inches to Millibars

In.	Milli-bars	In.	Milli-bars	In.	Milli-bars	In.	Milli-bars	In.	Milli-bars	In.	Milli-bars	In.	Milli-bars
27.50	931.3	28.00	948.2	28.50	965.1	29.00	982.1	29.50	999.0	30.00	1,015 9	30.50	1,032.9
27.51	931.6	28.01	948.5	28.51	965.5	29.01	982 4	29.51	999.3	30.01	1,016 3	30.51	1,033.2
27.52	931.9	28 02	948.9	28.52	965.8	29.02	982.7	29.52	999.7	30.02	1,016.6	30.52	1,033.5
27.53	932.3	28.03	949.2	28.53	966.1	29.03	983.1	29.53	1,000.0	30.03	1,016.9	30.53	1,033.9
27.54	932.6	28 04	949.5	28.54	966.5	29.04	983.4	29.54	1,000.3	30 04	1,017.3	30.54	1,034 2
27.55	933.0	28.05	949.9	28.55	966.8	29.05	983 7	29.55	1,000.7	30.05	1,017.6	30.55	1,034.5
27.56	933.3	28.06	950.2	28.56	967.2	29.06	984 1	29.56	1,001.0	30.06	1,018.0	30.56	1,034.9
27.57	933 6	28.07	950.6	28.57	967.5	29 07	984.4	29 57	1,001.4	30.07	1,018.3	30.57	1,035.2
27.58	934.0	28.08	950.9	28.58	967 8	29.08	984.8	29.58	1,001.7	30.08	1,018.6	30.58	1,035.6
27.59	934.3	28.09	951.2	28.59	968.2	29.09	985.1	29.59	1,002.0	30.09	1,019.0	30.59	1,035.9
27.60	934.6	28.10	951 6	28.60	968.5	29.10	985.4	29.60	1,002.4	30 10	1,019.3	30.60	1,036.2
27.61	935.0	28.11	951.9	28.61	968.8	29.11	985 8	29.61	1,002.7	30.11	1,019.6	30.61	1,036.6
27.62	935.3	28.12	952 3	28.62	969.2	29.12	986.1	29.62	1,003.1	30.12	1,020.0	30.62	1,036.9
27.63	935 7	28.13	952.6	28.63	969 5	29.13	986.5	29.63	1,003.4	30.13	1,020.3	30 63	1,037 3
27.64	936.0	28.14	952.9	28.64	969.9	29 14	986.8	29.64	1,003.7	30.14	1,020.7	30.64	1,037 6
27.65	936.3	28.15	953.3	28.65	970.2	29.15	987.1	29.65	1,004.1	30.15	1,021 0	30 65	1,037 9
27.66	936.7	28.16	953 6	28.66	970.5	29.16	987 5	29.66	1,004.4	30.16	1,021 3	30 66	1,038.3
27.67	937.0	28.17	953.9	28.67	970 9	29.17	987 8	29.67	1,004.7	30.17	1,021 7	30 67	1,038.6
27.68	937.4	28.18	954 3	28.68	971.2	29.18	988.2	29.68	1,005.1	30.18	1,022.0	30 68	1,038 9
27.69	937.7	28 19	954.6	28.69	971 6	29.19	988.5	29.69	1,005 4	30 19	1,022 4	30 69	1,039 3
27 70	938.0	28.20	955.0	28 70	971.9	29.20	988 8	29 70	1,005 8	30 20	1,022 7	30 70	1,039.6
27.71	938.4	28.21	955 3	28.71	972.2	29 21	989.2	29.71	1,006.1	30 21	1,023 0	30 71	1,040.0
27.72	938 7	28.22	955.6	28 72	972 6	29 22	989.5	29.72	1,006.4	30.22	1,023 4	30 72	1,040.3
27.73	939.0	28.23	956 0	28.73	972.9	29.23	989.8	29.73	1,006.8	30.23	1,023 7	30 73	1,040 6
27.74	939.4	28.24	956 3	28 74	973 2	29 24	990 2	29 74	1,007 1	30 24	1,024 0	30 74	1,041 0
27.75	939.7	28.25	956 7	28.75	973.6	29 25	990.5	29 75	1,007 5	30 25	1,024 4	30.75	1,041 3
27.76	940 1	28 26	957.0	28.76	973.9	29.26	990.9	29 76	1,007 8	30 26	1,024 7	30.76	1,041 7
27 77	940.4	28.27	957.3	28 77	974 3	29.27	991.2	29.77	1,008 1	30 27	1,025 1	30 77	1,042 0
27.78	940.7	28 28	957.7	28.78	974 6	29 28	991 5	29.78	1,008 5	30 28	1,025 4	30 78	1,042 3
27.79	941 1	28 29	958 0	28.79	974.9	29 29	991.9	29.79	1,008 8	30 29	1,025 7	30 79	1,042 7
27.80	941 4	28 30	958 3	28 80	975.3	29 30	992.2	29 80	1,009.1	30 30	1,026 1	30 80	1,043 0
27.81	941 8	28.31	958 7	28.81	975 6	29 31	992.6	29 81	1,009 5	30 31	1,026 4	30 81	1,043 3
27 82	942 1	28.32	959.0	28 82	976 0	29 32	992 9	29 82	1,009 8	30 32	1,026 8	30 82	1,043.7
27 83	942 4	28 33	959.4	28 83	976 3	29.33	993 2	29.83	1,010 2	30 33	1,027 1	30 83	1,044 0
27 84	942 8	28.34	959.7	28.84	976.6	29 34	993 6	29 84	1,010 5	30 34	1,027 4	30 84	1,044 4
27 85	943 1	28 35	960 0	28 85	977 0	29 35	993.9	29 85	1,010 8	30 35	1,027 8	30 85	1,044 7
27 86	943 4	28.36	960.4	28.86	977 3	29.36	994 2	29 86	1,011 2	30 36	1,028 1	30 86	1,045 0
27.87	943.8	28.37	960 7	28 87	977 7	29 37	994 6	29 87	1,011 5	30 37	1,028 4	30 87	1,045 4
27 88	944.1	28 38	961.1	28.88	978 0	29 38	994 9	29 88	1,011.9	30 38	1,028.8	30 88	1,045 7
27 89	944 5	28.39	961.4	28 89	978.3	29.39	995 3	29 89	1,012.2	30 39	1,029 1	30 89	1,046 1
27 90	944 8	28.40	961.7	28 90	978.7	29 40	995 6	29 90	1,012 5	30 40	1,029 5	30 90	1,046 4
27.91	945.1	28.41	962.1	28.91	979.0	29.41	995 9	29.91	1,012 9	30 41	1,029 8	30 91	1,046 7
27.92	945 5	28 42	962.4	28 92	979 3	29.42	996.3	29.92	1,013.2	30 42	1,030 1	30 92	1,047 1
27 93	945.8	28.43	962.8	28.93	979.7	29 43	996.6	29.93	1,013.5	30 43	1,030 5	30 93	1,047 4
27 94	946.2	28.44	963.1	28.94	980.0	29.44	997 0	29 94	1,013.9	30 44	1,030 8	30.94	1,047 8
27 95	946.5	28.45	963.4	28.95	980.4	29.45	997.3	29 95	1,014.2	30 45	1,031 2	30.95	1,048 1
27 96	946 8	28.46	963.8	28 96	980.7	29 46	997.6	29.96	1,014 6	30.46	1,031.5	30 96	1,048 4
27.97	947.2	28.47	964.1	28 97	981 0	29.47	998.0	29.97	1,014.9	30.47	1,031.8	30 97	1,048 8
27.98	947.5	28.48	964.4	28.98	981.4	29.48	998 3	29.98	1,015.2	30.48	1,032.2	30 98	1,049 1
27.99	947 9	28.49	964.8	28 99	981.7	29 49	998.6	29.99	1,015.6	30 49	1,032.5	30 99	1,049 5

in Buys Ballot's law, because of topographic effects. (Buys Ballot's law: When you stand with your back to the prevailing wind in the Northern Hemisphere, the high-pressure area is to your right. The reverse is true in the Southern Hemisphere.)

With Buys Ballot's law in mind, study figure 5-11. Both Key West and Miami report 1,104 mb and a northwest wind. The region of lower barometric readings must, therefore, be eastward, or to the right of the stations. If we trace the isobar from St. Thomas with the wind, all barometric readings higher than 1,106 mb must be to the right. You can see that ships A and B report 1,106 mb and a southwest wind. As a result, your line should curve around to follow the wind and pass just left of both ships.

Ship C, to the north-northwest of ship B, reports 1,106 mb, wind northeast. Between ships B and C, the wind evidently backs from south to northeast. Then the isobar must back, too, counterclockwise, so that it takes a trend to the southwest in passing through the position of ship C. Cape Hatteras (near Wilmington, North Carolina) reports 1,106 mb and a northeast wind. The isobar follows the wind southwestward to Hatteras, with readings of more than 1,106 mb lying to its right. The rule still is observed then that when the isobar is traced with the wind, it is kept to the left of all points where pressure is higher than its assigned value. Continuing with the wind, it passes through Charleston, to the north of Jacksonville, and then through the Gulf to its starting point.

Ship D reports 1,106 mb and a northwest wind. It is evident, then, that another isobar must start here. Tracing it into the wind this time, we must remember that in this example it must be kept to the right of all points where pressure is higher than its assigned value. Thus it runs through ship D, curving northwestward to pass between Nantucket and to Halifax.

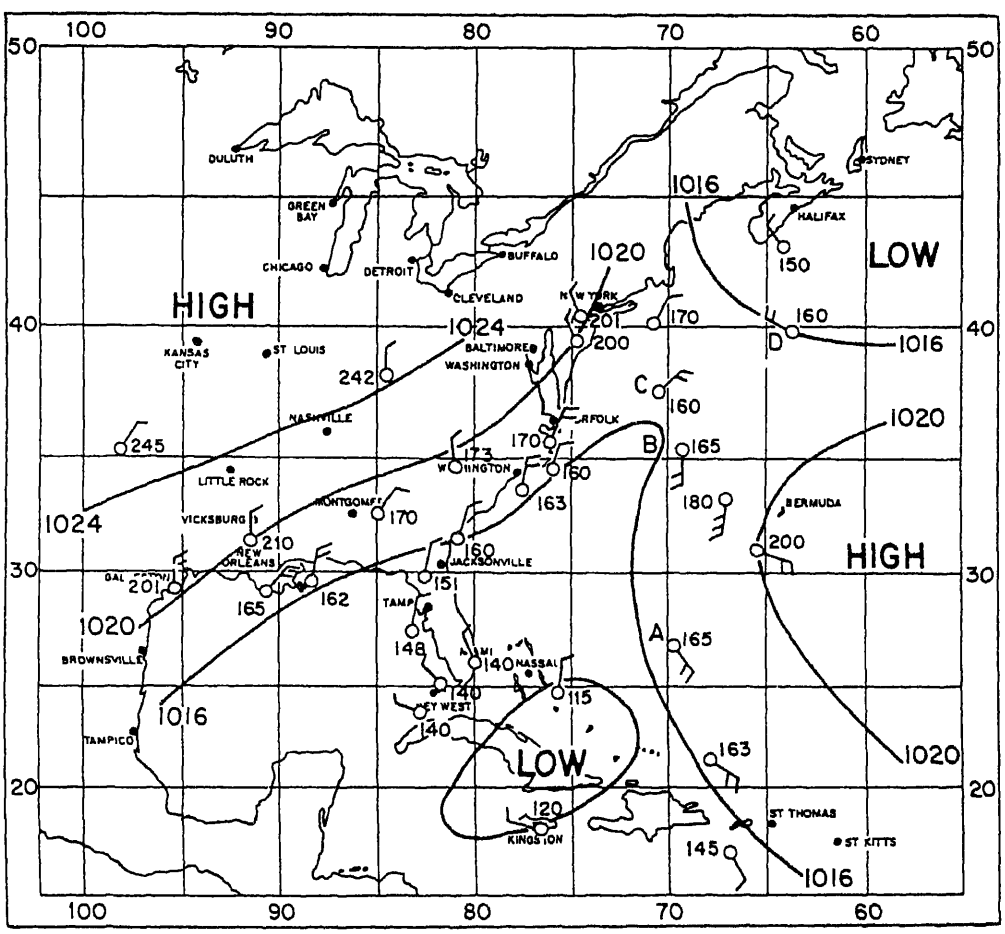


Figure 5-11.—Weather chart (1).

In representing large-scale movement of the air, simple isobars are more probable than complicated isobars. See figure 5-12; on the left is an example of how a beginner would draw isobars to fit barometric readings precisely. On the right the isobars are correctly drawn to take shape of smooth lines. An irregular appearance frequently is caused by minor errors in observations. Hence, irregularities that do not show any systematic arrangement are likely to be the reflection of errors. If a reported pressure seems incorrect, compare it with the previous report from the same station to determine whether the pressure change is probable.

Isobars must always appear as simple curved lines or as closed lines. Isobars may begin and end in the following manner:

1. An isobar may originate on one edge of the chart, trace a path connecting points of equal pressure values, and terminate on any edge.
2. An isobar may begin anywhere on the chart, trace a path connecting points of equal pressure values, and join ends to form a closed curve.

ISOBARS REPRESENTING DIFFERENT PRESSURE VALUES NEVER TOUCH OR CROSS. Touching or crossing would signify two different pressures at the same time and place, which is impossible.

In drawing isobars over large areas, start in a region where they are easy to draw. Drawing isobars over land areas, where there are a large number of reports, is less difficult than over ocean areas, where reports are limited. The best method is to draw isobars over adjacent oceans. Other conditions being equal, it is easier to draw isobars in areas of strong wind than where the winds are weak. Isobars should be drawn so they agree logically with the preceding chart. Suppose, for example, that the preceding chart shows a young

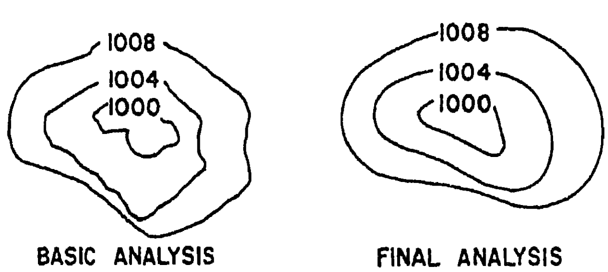


Figure 5-12.—Smoothing of isobars.

deepening cyclone. The present chart should show that the low has moved a reasonable distance and deepened. The deepening is indicated by new closer isobars around the center.

In drawing an isobar, keep in mind that the higher pressures are on one side of the isobar and the lower pressures are on the other side. (See fig. 5-13.) If pressures higher (or lower) than the value of the isobar itself are on both sides of the isobar, you have made a mistake.

TWO-STATION METHOD OF ISOBARIC ANALYSIS.—The two-station method of analysis is a very good way to begin and complete the basic analysis.

The first step in the two-station method is to select an area of the chart overland where numerous reports are available. Locate an area of highest or lowest plotted pressure values. Select either the high- or the low-pressure area to begin your analysis. Let us say you selected the low-pressure area; now find the station with the lowest plotted pressure value. Note this pressure value. Then go in any direction from this station to a station immediately adjacent. Determine what standard isobaric value, if any, fits between these two stations in a logical numerical order. If a standard isobar can be drawn between these two stations, draw a short pencil line between them more or less parallel with the wind shafts at the two stations. If a standard isobar does not fit between the two stations, continue in the same direction to the next adjacent station and repeat the process.

Note the plotted pressure values at several stations immediately downwind from the point of origin. If the numerical value of the isobar being drawn fits between two of these downwind stations, project the short line being drawn to this new point. Repeat the search, always downwind. Project the isobar to the new point Repeat this procedure until the isobar being drawn runs off one edge of the chart, returns to the point of origin (the ends join to form a closed curve), or enters an area where there are no reports and there is no reason to continue.

Remember that all points along an isobar represent the same numerical pressure value. Then move from the finished isobar, at any point, outward to an adjacent station. Determine if you can place another isobar of greater or lesser value between this station and the isobar just completed. If so, proceed in the same manner outlined above. If not, continue in the same direction to the next adjacent station. You will eventually find an area

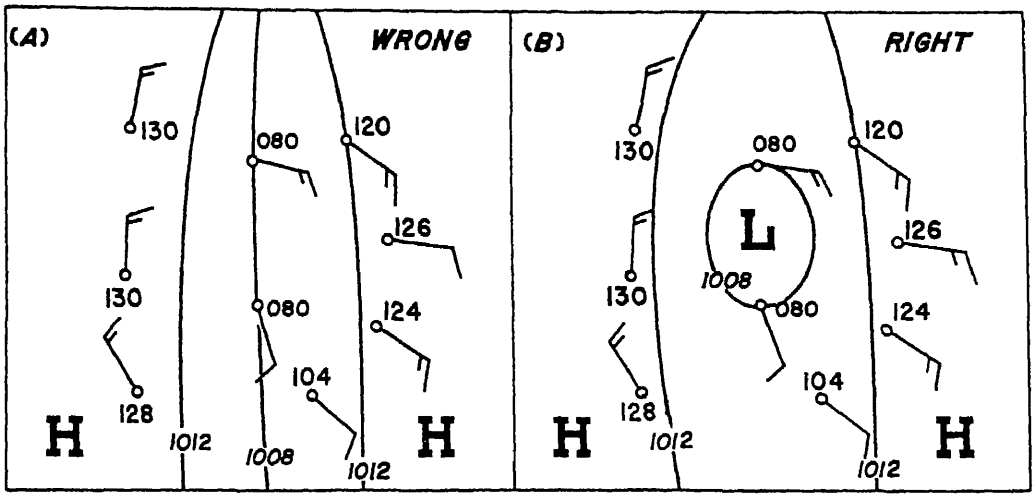


Figure 5-13.—A small pressure center between isobars.

between the two stations where the next standard isobar may be drawn. You may then proceed in the manner outlined above.

Repeat this process until you have drawn an isobar for all standard values insofar as the plotted information permits.

ERRORS IN BAROMETRIC REPORTS.— A barometer report may be incorrect for one or more of the following reasons:

1. Inaccuracy of the instrument used
2. Incorrect reading of the barometer
3. Error in applying corrections to observed readings
4. Error through failure to make observation at the exact GMT
5. Error in coding or transmission
6. Error resulting from limitations of the code

You cannot identify an instrumental error positively unless you can compare three or four observations from one ship with those from a nearby ship or land station.

Small errors in readings are difficult to detect. Large errors are usually the result of misreading inches or millibars, depending on the scale of the instrument. In these instances, it is possible, ordinarily, to deduce what the reading should have been.

Errors in coding usually result from (1) entering the last two figures into the coded message in inches instead of millibars, or (2) selecting the wrong figures in the code table. If two ships in the same locality report readings that are in agreement with each other but drastically different from those of a third ship nearby, it often is possible to determine just how the observer on the third ship made his or her error.

Errors in transmission nearly always are the result of changing a figure by one unit or of transposing two or more figures in a group. If an error of the first type occurs in the last figure of the report, it will not be especially significant. Such an error in the first figure, however, produces an error in the result of 10 millibars (approximately 0.30 inch). Transposition of figures, of course, produces large errors.

A special kind of error is caused by incorrectly reporting the ship's position In that event the barometric reading does not "fit" the reported position, and you are likely to assume that the reading is erroneous instead of the position. Likewise, errors of position throw other elements of the weather report out of harmony with the vicinity. They usually amount to 1° or even 10° in latitude or longitude. If the reporting ship's position is tracked carefully from chart to chart, you can usually detect position errors.

Errors resulting from limitations of the international code are not serious. The code is accurate to within 1 millibar (0.30 inch), so that these errors will be no greater than 0.5 millibar (0.015 inch).

You can usually identify and correct errors caused by a mistake in decoding or in plotting the ship's position.

Illustrative Examples

Figure 5-14 shows a system of isobars drawn to fit each barometric report. The rule requiring that all points of high pressure be on the same side of the line has been observed.

The rule states that the isobars should be drawn to place them in the best possible agreement not only with barometric readings but also with Buys Ballot's law. In this instance they are in agreement.

Examination of the wind reports here seems to indicate a normal situation. A uniform airstream is flowing southwest fairly rapidly between Bermuda and Hatteras, decreasing in speed and curving westward off the east coast of Florida. Because wind observations normally are more accurate than barometric reports, you must fair these isobars to agree with the wind reports. To do this, you usually must reject one or more of the barometric reports.

It is safe to assume that barometric reports from shore stations are fairly accurate. Miami reports 1,020 millibars. Considering the wind direction, then, the 1,020 isobar should run east-northeast from Miami, and the barometric reading from ship E is too high. Assuming that ship D's barometric report is probably correct, then ship C's is too low and should be rejected. Continuing the isobar into the wind, it appears that the 1,025 millibar report from ship G should lie to the left, on the side of the higher pressure.

Now consider the 1,024 isobar. It should run eastward from a point just south of Jacksonville, because that station reports 1,025 millibars, wind northeast. Obviously, then, the barometric report from ship A must be too high. When the line is extended toward ship F, it becomes apparent that, although ship G's reading fits in fairly well, drawing the line south of ship F to conform to a report of 1,024 millibars will make the isobars crowded near Bermuda and widely separated near Hatteras. This spacing would indicate a radical

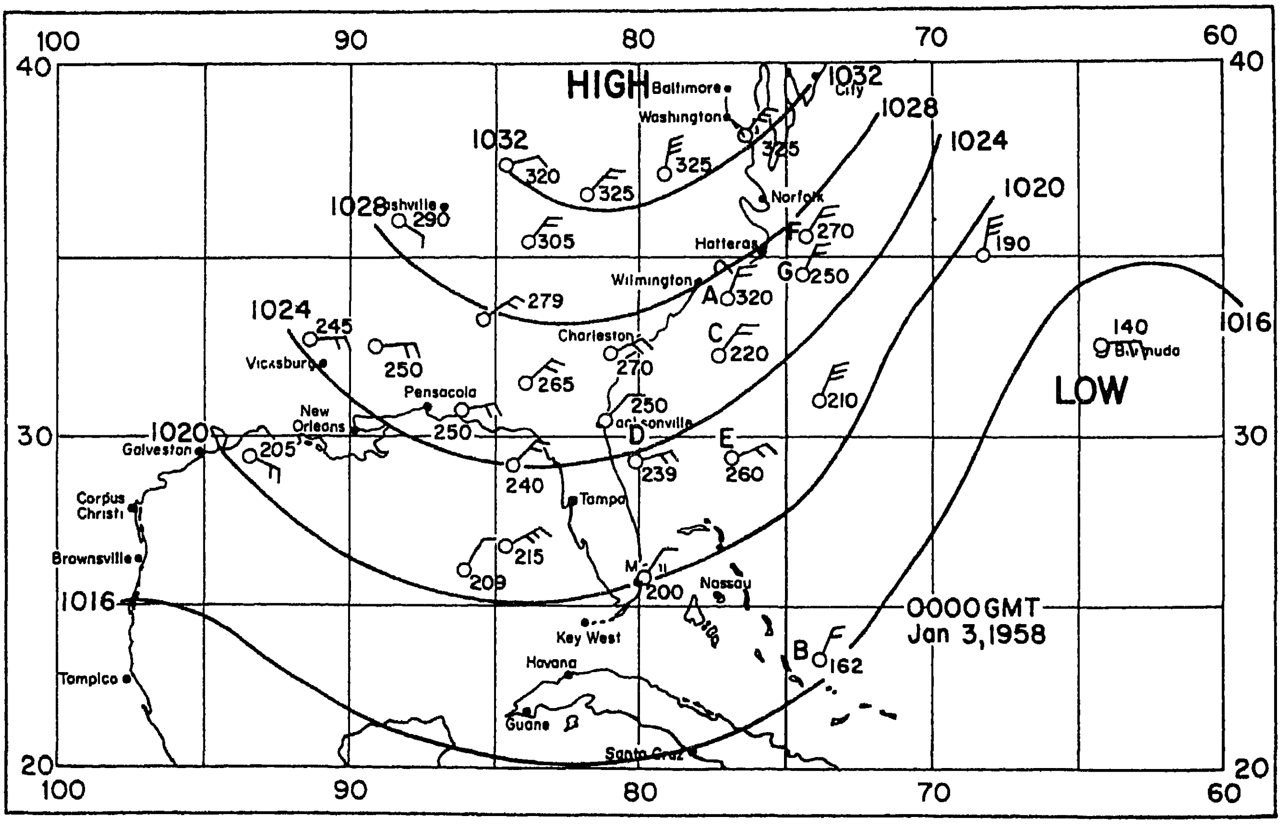


Figure 5-14.—Weather chart (2).

erence in wind velocity at these two points. wind reports, however, indicate uniform city over the entire stretch between Hatteras Bermuda, requiring that the isobars be spaced ly here. Ship A's barometric reading, then, o high, so you ignore it in fairing the isobars. distance between the isobars as drawn is in llent agreement with table 5-1 for a force-6 d in the same latitude.

Figure 5-15 shows you how the proper fairing he isobars indicates clearly an area of low sure, which soon developed into a hurricane. e the barometric reports from ships A and B in good agreement with each other. To nonize with them, the 1,004 isobar has been nded north from Nassau, and carried just to west of ships A and B. Barometric and wind rts at Jacksonville indicate that the line ld curve sharply to the southwest from a point just northwest of ship A. The 1,008 isobar is curved to the north near ship C to agree.

The report of a light west wind and high barometric reading from ship D fits in logically and indicates the presence of a separate anticyclone center. Also, there is the possibility of a pronounced wind-shift line between Bermuda and ship D. Knowledge of such a line (or front) approaching here is extremely valuable to ship D.

Weather Forecasting from Isobars (Frontal Analysis)

The next step in analysis is to locate and sketch frontal positions. Careful isobaric analysis is a great help in locating the more obvious fronts.

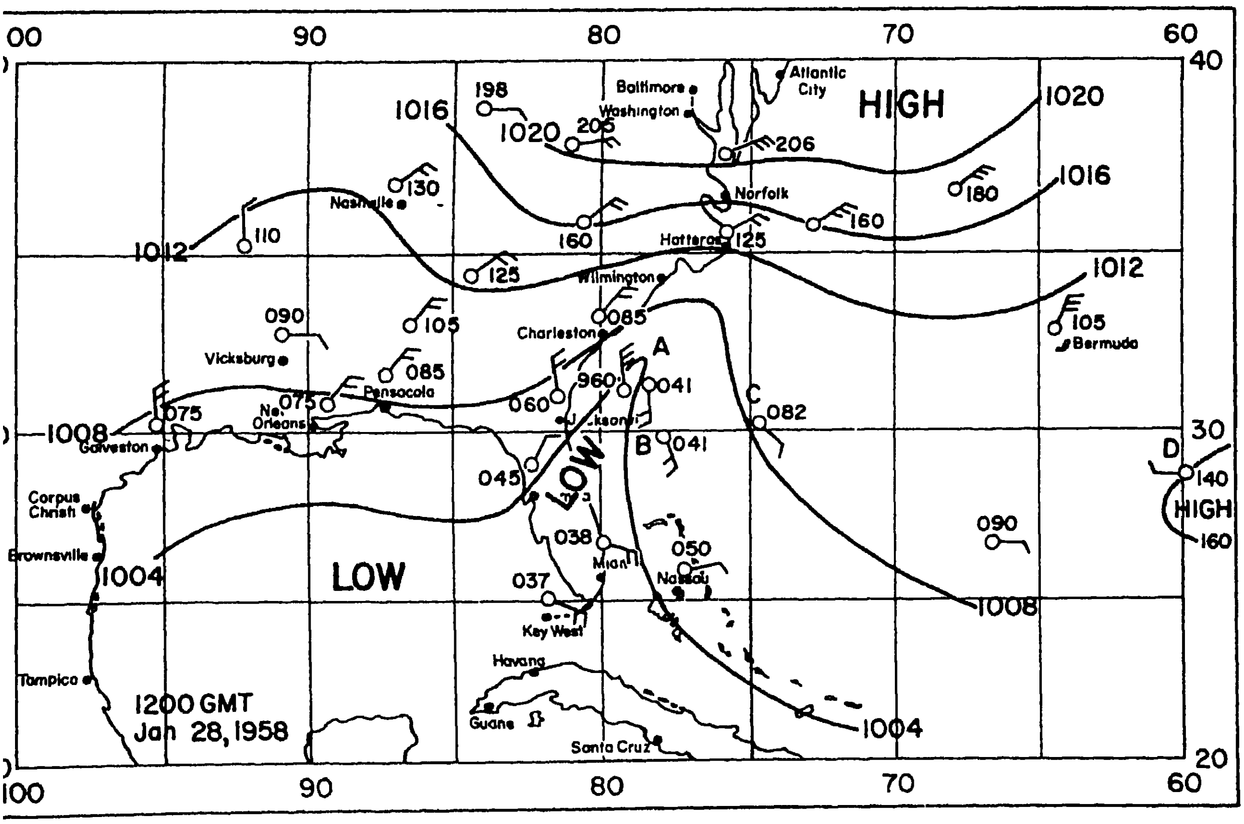


Figure 5-15.—Weather chart (3).

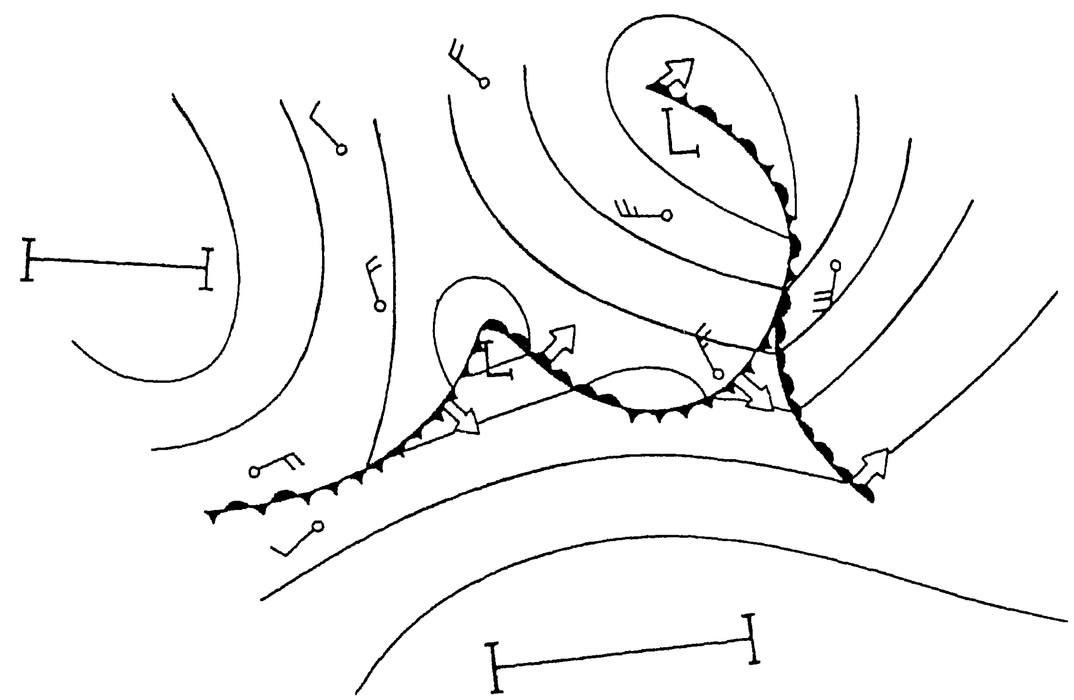
Figure 5-16 illustrates charted weather fronts designations.

The location of fronts is determined by past history, air mass analysis, satellite data, and reports on the present charts. Fronts and their accompanying weather move across various areas of Earth in established directions with somewhat definite speeds. Therefore, you can follow their movement on previous charts to help locate them at any particular time.

To locate fronts, you should study properties of the air masses and then locate the fronts so that they separate unlike air masses.

WARM FRONTS.—Active warm fronts are generally located in pressure troughs on surface charts. See figure 5-17. The troughs are not as pronounced as those observed with cold fronts; therefore, other meteorological elements are used, as follows, in locating warm fronts accurately:

1. Pressure tendencies. Pressure usually falls for an appreciable length of time before the front passes. Normally, it is steady after passage. The tendencies in advance of the front are therefore \ (steady or unsteady fall). A warm frontal passage is usually indicated by a _ tendency.



Type	LEGEND Symbol	Coloring
COLD FRONT		BLUE LINE
WARM FRONT		RED LINE
OCCLUDED FRONT		PURPLE LINE
STATIONARY FRONT		ALTERNATE RED & BLUE
UPPER COLD FRONT		DASHED BLUE LINE

Figure 5-16.—Designation of fronts on weather charts.

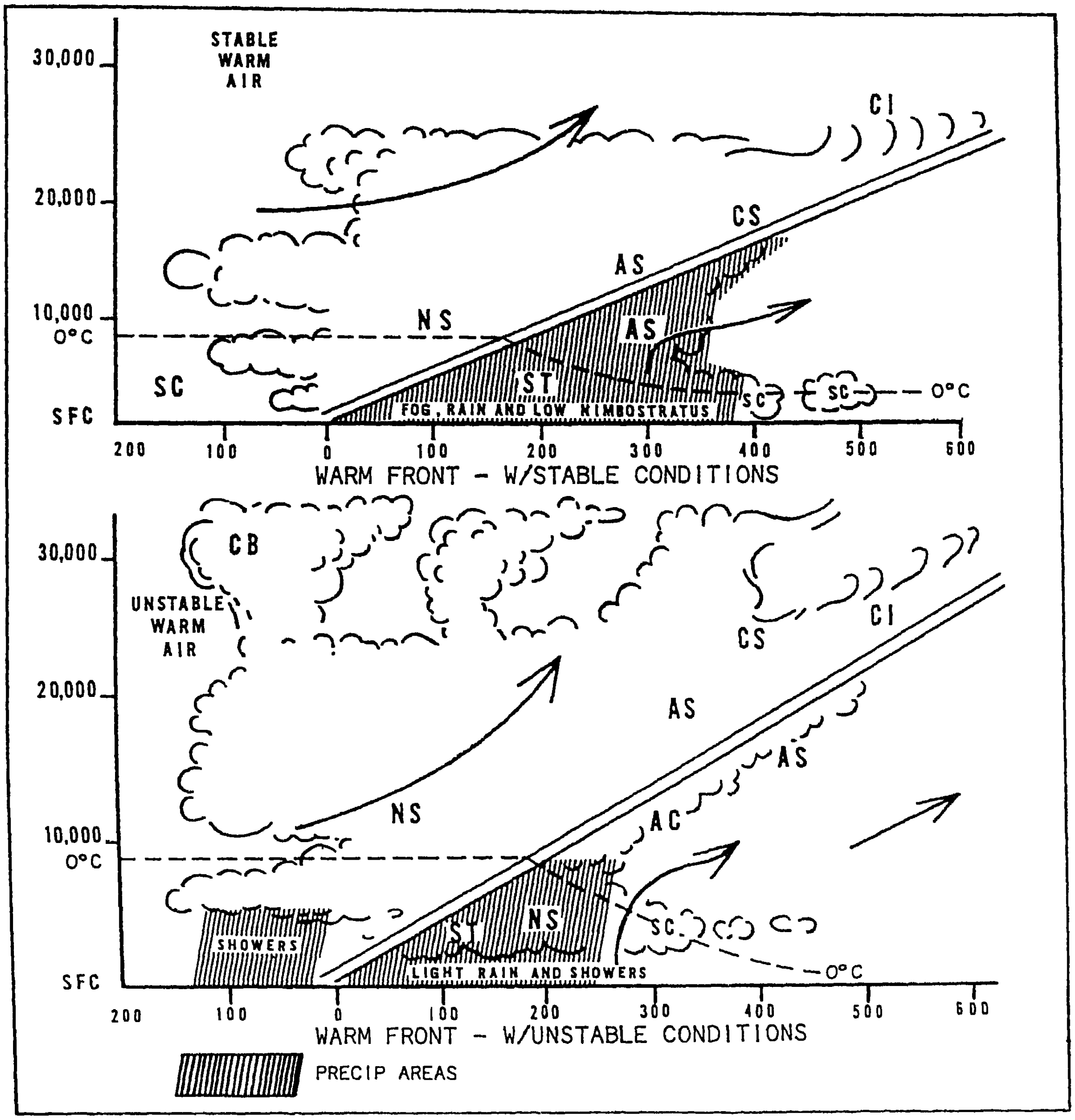


Figure 5-17.—Vertical cross section of a warm front

2. Wind. The wind in advance of a warm front in the Northern Hemisphere is usually from the southeast, shifting to southwest after passage. The wind speed normally increases as the front approaches. The wind shift accompanying a warm front is seldom as abrupt as with a cold front.

3. Cloud forms. Warm fronts are nearly always well defined by tropical stratified clouds. They are generally cirrus, cirrostratus, altostratus, nimbostratus, and stratus, with the cirrus appearing as much as 1,000 miles before the actual surface passage. The cloud types that form after passage of the warm front are typical of the warm air mass.

4. Precipitation The precipitation area of warm fronts extends about 300 miles in advance of the surface front. Precipitation occurs mainly in the form of continuous or intermittent rain, snow, or drizzle. However, when the warm air is convectively unstable, showers and thunderstorms may occur in addition to the steady precipitation.

5. Temperature and dew-point changes. Abrupt temperature changes, like those characteristic of cold fronts, do not accompany the

warm frontal passage. Instead, the temperature change is gradual. It starts increasing slowly with the approach of the front and increases slightly more rapidly with the passage. The dew-point is normally observed to rise as the front approaches, and a further increase follows the frontal passage when the air in the warm sector is of maritime origin.

6. Visibility and ceiling. The visibility and ceiling are normally good until the precipitation begins. Then they decrease rapidly. Dense fog frequently occurs in advance of a warm front. These conditions improve after the front passes.

COLD FRONTS.—Cold fronts are normally located in well-defined pressure troughs whenever there is a marked temperature contrast between two air masses. In most cases, a careful analysis of the isobars indicates the correct position of the pressure trough that contains the front. This method of isobaric analysis is frequently the only possible means of locating fronts over ocean areas or regions of scanty surface reports. Other indications of cold fronts can be classified as prefrontal, frontal, or postfrontal as follows (see fig. 5-18):

1. Pressure tendencies. In advance of cold fronts, the tendency characteristic is usually indicated by a steady or unsteady fall. The isobars of falling pressure in advance of the front usually form an elongated pattern approximately parallel to the front. After the passage of the front, the tendency generally shows a steady rise, and stations behind the front show a tendency characteristic of \/, ✓, or /. The first two, showing a fall and then a rise in pressure, indicate that the front passed the station during the 3-hour period prior to chart time.

2. Wind. With the approach of the front, the wind is normally from the south or southwest in the Northern Hemisphere, veering to parallel the front. At the passage, the wind generally shifts abruptly to the northwest. Very gusty winds frequently occur at the frontal passage and usually after passage.

3. Cloud forms. In advance of cold fronts, the cloud types are typical of the warm air. Towering cumulus, cumulonimbus, stratocumulus, and nimbostratus are associated with the passage. After passage, these cloud forms may prevail for several hundred miles with the slow-moving cold front. Very rapid clearing conditions are associated with the fast-moving cold front after passage. Well back in the cold air in both types of cold fronts, the only clouds normally found are fair-weather cumulus.

4. Precipitation. Showers and sometimes thunderstorms occur as a cold front passes. Continuous precipitation is observed from some hours after passage of a slow-moving cold front. Showers and thunderstorm activity of short duration will occur with the passage of a fast-moving cold front, followed by very rapid clearing conditions.

5. Temperatures. Temperature is relatively high before passage. After passage, the temperature decreases very rapidly with slow-moving fronts. Such a rapid temperature change does not accompany the passage of fast-moving cold fronts; the real temperature change is usually seen some distance (as far as 50 to 100 miles) behind the front.

6. Dew-point. The dew-point temperature generally helps to locate fronts. This is especially true in mountainous regions. A drop in the dew-point is observed with the passage of either type of cold front.

7. Visibility and ceiling. With the approach and passage of a slow-moving cold front, the visibility and ceilings decrease and remain low after the passage until well within the cold air. Fast-moving cold fronts are preceded by regions of poor visibility and low ceilings due to shower activity. After passage of fast-moving cold fronts, the ceiling rapidly becomes unlimited and the visibility unrestricted.

OCCLUDED FRONTS.—Because the occlusion is a combination of a cold front and a warm front, the resulting weather is a combination of conditions that exist with both fronts. Ahead of a cold-type occlusion, as the warm air is lifted, all clouds associated with a warm front are found producing typical prefrontal precipitation extensively for a distance of 250 to 300 miles. Typical cold front weather is found throughout the narrow belt in the vicinity of the surface front. However, the thunderstorms are less intense than those of a typical cold front. This occurs because the source of warm air has been cut off from the surface, and the energy received comes only from the warm air trapped aloft. Instability showers often follow the cold front when the cold air is unstable. The most violent weather occurs on the upper front for a distance of 50 to 100 miles north of the northern tip of the warm sector. After the

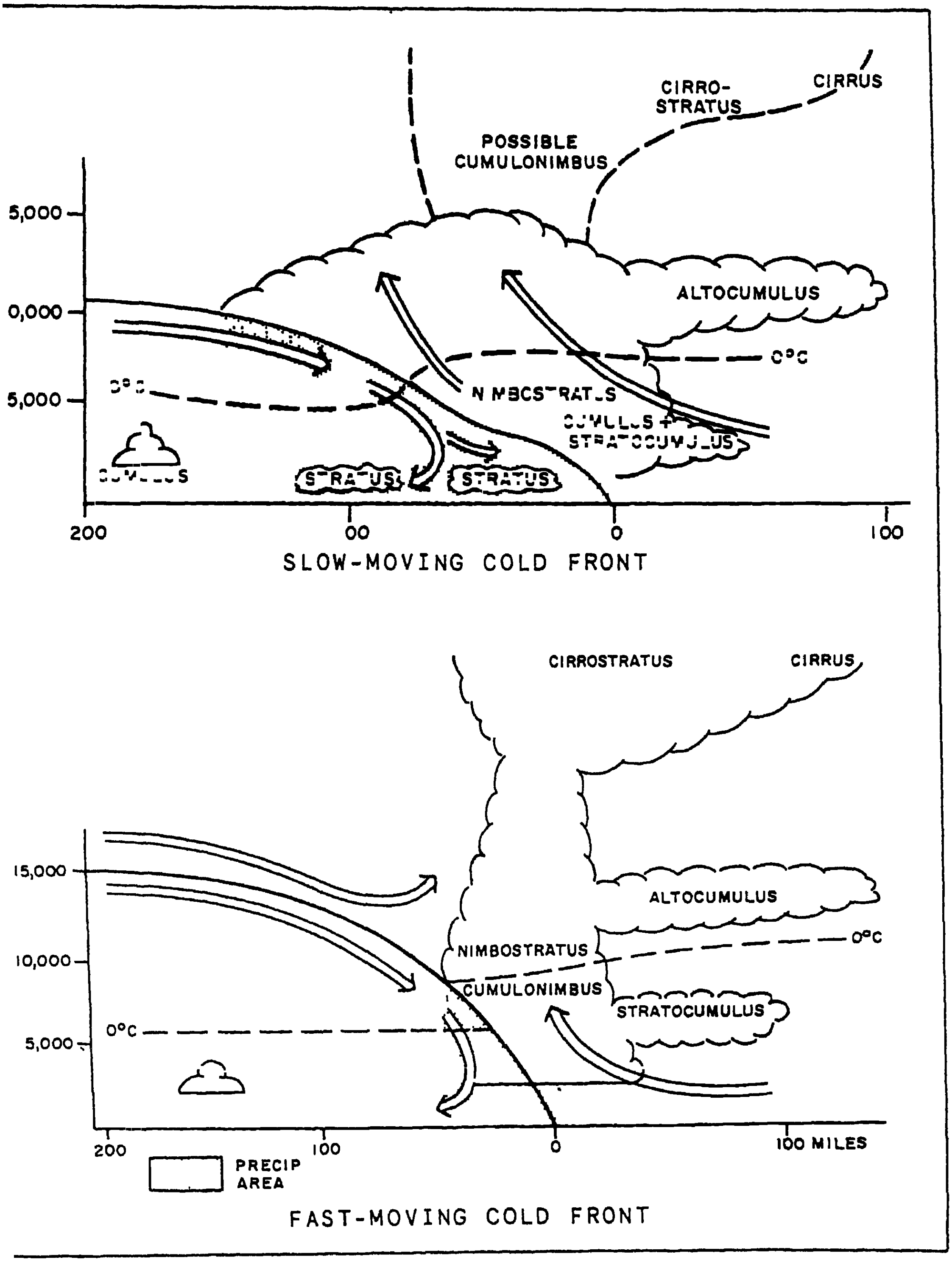


Figure 5-18.—Vertical cross section of a cold front.

occlusion has passed, the weather usually clears rapidly. Figure 5-19 shows a vertical cross section of a warm-type occlusion, and figure 5-20, a cold-type occlusion.

The weather associated with the warm occlusion (fig. 5-19) is very similar to that of the cold occlusion. With the warm occlusion, the high-level thunderstorms associated with the upper cold front develop quite some distance ahead of the surface front (up to 200 miles), and the weather band, in general, is wider (up to 400 miles). The air behind the cold front, flowing up the warm frontal surface, causes cumuliform-type clouds to form. In this area, precipitation and severe icing may be found. The most violent weather occurs on the upper front, 50 to 100 miles north of the northern tip of the warm sector.

FRONTS AND ISOBARS.—The pronounced weather changes that accompany a front are caused by the air currents on its opposite sides. These air currents originate in more or less widely separated geographical areas that have contrasting meteorological properties. For this reason, careful study of wind and pressure fields is essential in drawing isobars correctly, especially in ocean areas where weather reports could be widely scattered. As an example, isobars drawn in a conventional circular pattern around a cyclone fail to give you a true picture of the motion of existing fronts. Therefore, you are unable to tell when you may expect a pronounced shift of wind. Isobars

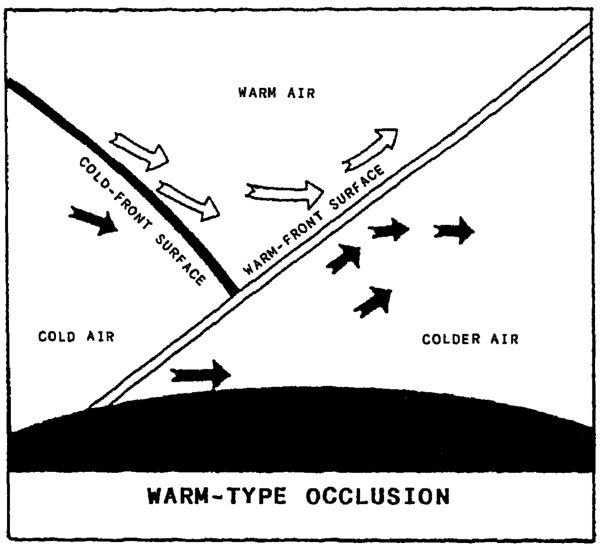


Figure 5-19.—Vertical cross section of a warm-type occlusion.

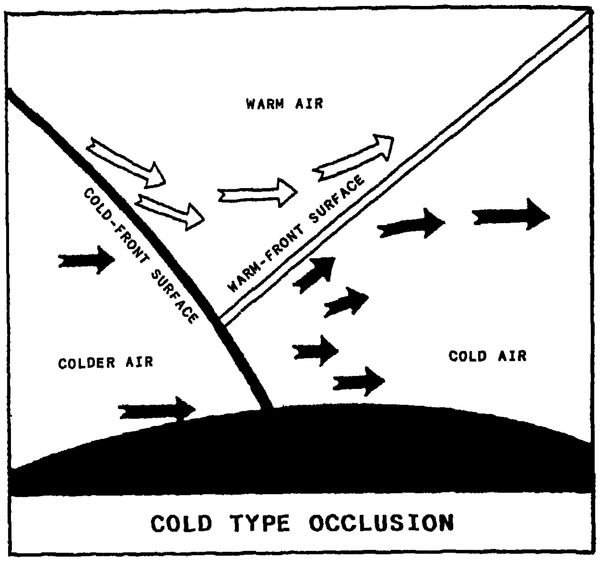


Figure 5-20.—Vertical cross section of a cold-type occlusion.

that locate weather fronts properly provide a tangible base for detailed forecasting.

The speed of movement of a cold front depends on the speed at which the air on the left side of the front (as you face toward the low pressure) is advancing in the direction perpendicular to the front. The speed of movement of a warm front is slower than cold fronts, usually between 10 and 20 knots. The rule for determining the movement of warm fronts states that a warm front will move with a speed of 60 to 80 percent of the component of geostropic wind normal to the front in the warm air mass. Therefore you can calculate, from wind observation alone, the rate at which a front is moving. If wind reports are lacking, you must rely on the distance between isobars. You can see how important it is to have spaced them properly.

If correctly drawn isobars are crowded at one portion of a front and widely spaced at the other, it is obvious that the latter portion is lagging behind, causing a wavelike deformation of the front. A new cyclone is quite likely to be developed at this point. In general, a front remains stationary or moves very slowly when the winds on the cold side are blowing parallel (or nearly so) to the front.

WINDS AND PRESSURE AREAS

The atmosphere in which we live has definite weight called atmospheric pressure. This pressure,

measured by a barometer, varies with the presence of water vapor. Water vapor, in turn, differs in amount according to temperature. When a large volume of air is heated, it becomes light and rises. Then the adjacent heavy air rushes to seek its own level, so to speak, which produces a flow of air, called wind. The actual circulation of the air is influenced greatly by Earth's rotation and other factors. Because of this, winds do not always blow continuously and steadily from cool areas of high atmospheric pressure to warmer regions where pressure is lower.

Winds tend to follow closely the seasonal variations of pressure areas. Because pressure is influenced by temperature, these pressure areas tend to follow the movement of the sun in declination. Study and observation over a long period have located various well-defined pressure areas on Earth's surface.

First, relatively low pressure lies along the equator, where the average barometric reading is about 29.90. On either side of this area is a belt where pressure is average. These belts lie between 30°N and 40°N between 30°S and 40°S. Above and below the high-pressure belt, average atmospheric pressure diminishes toward the poles. In the Southern Hemisphere this decrease in pressure is regular and obvious. It is less regular and not so obvious in the Northern Hemisphere. There are local centers of low pressure near the Aleutian Islands in the North Pacific and near Iceland in the North Atlantic. Pressure in these areas averages 29.70 inches, increasing again to the north.

WORLD WINDS

The following paragraphs deal with the general (surface) circulation with prevailing winds and nearby permanent pressure systems or belts. (See fig. 5-21.) Remember that in the Northern Hemisphere the circulation is clockwise about high-pressure areas (called an anticyclone) and counterclockwise about low-pressure areas (called a cyclone). The reverse is true in the Southern Hemisphere. At times confusion arises from the meaning of wind direction. Wind is always named by the direction from which it is blowing.

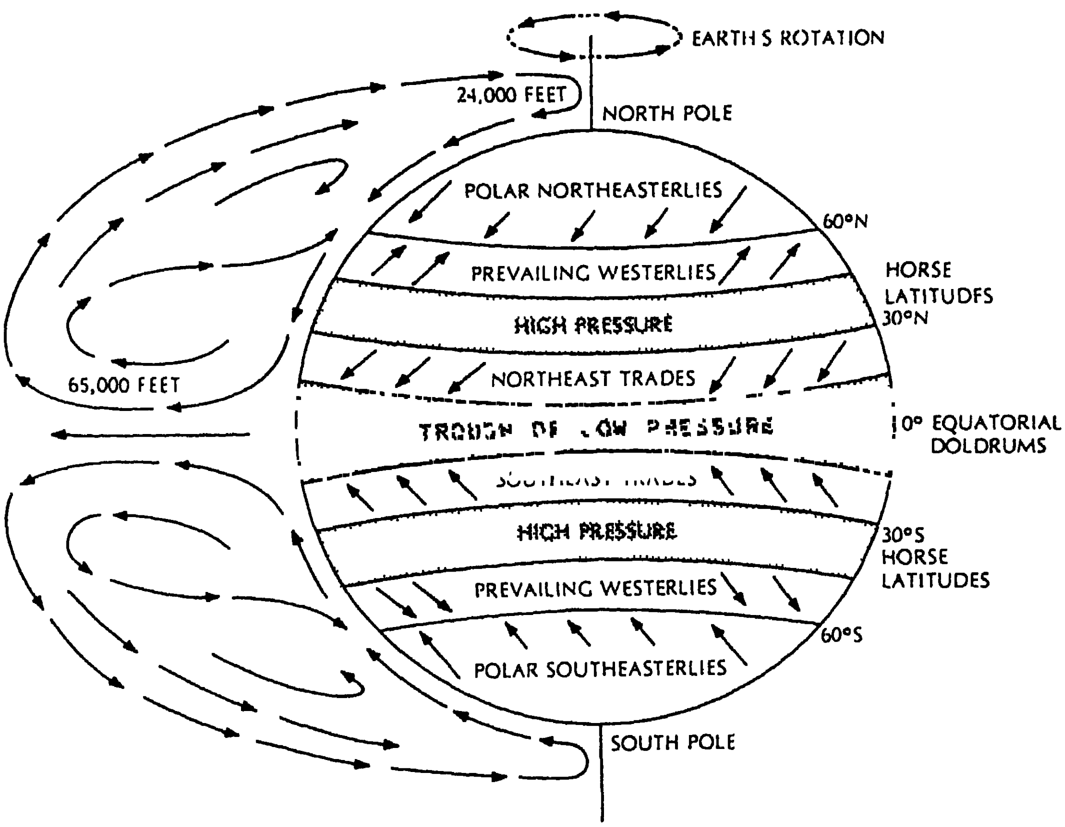


Figure 5-21.—General circulation of air.

The equatorial belt of light and variable winds, between the northeast trade winds of the Northern Hemisphere and the southeast trade winds of the Southern Hemisphere, is called the doldrums, or the intertropical convergence zone.

The doldrums vary in position. They tend to move north and south of the equator with the sun, though more of the area is generally located slightly north of the equator. In the doldrums the temperatures are high and the wind convergent (a net inflow of air into the area). This causes greater rainfall.

The trade winds are found just north and south of the doldrums. Whenever the doldrums are absent in some part of the equatorial region, the trade winds of the Northern and Southern Hemispheres converge, causing heavy rain squalls. A feature of the trade wind belt is the regularity of the systems, especially over the oceans. (The wind blowing above and counter to the trade wind is the antitrade, formerly called the countertrade.)

The areas of the subtropical high-pressure cells, where the winds are light and variable, are about 30°N to 40°N and 30°S to 40°S. They are called the horse latitudes. Fair weather is characteristic of this region, due to the descending air.

The pressure decreases outward from this area, and the prevailing westerlies are on the poleward side, with the trade winds on the equatorial side.

The prevailing westerlies, which are on the poleward side of the trade winds, are persistent through the midlatitudes. In the Northern Hemisphere their direction at the surface is from the southwest, and in the Southern Hemisphere from the northwest. This is the result of the deflection caused by the Coriolis force as the air moves poleward. (The Coriolis effect is the apparent force exerted by the rotation of Earth.)

A belt of low pressure known as the polar front zone lies poleward of the prevailing westerlies.

In the polar cells, poleward of the polar front zone, the surface winds are known as the polar easterlies (polar northeasterlies at the North Pole and polar southeasterlies at the South Pole). They move from from the northeast in the Northern Hemisphere and from the southeast in the Southern Hemisphere. They are very shallow due to the low temperatures and are overlain by the westerlies. This circulation pattern is temporarily disrupted by migratory pressure systems in all areas but returns to the original pattern.

HEAVY WEATHER

Ordinary prevailing winds can become strong enough to raise some really respectable seas (such as the North Atlantic gale). A modern ship, though, usually suffers no serious damage from heavy weather unless she encounters winds of storm force or greater.

The two basic classes of weather disturbances are closed cyclonic (rotary) circulation storms, like tornadoes and hurricanes, and other than closed cyclonic circulation storms, like gales and squalls. Storms in either class can have a tropical or nontropical origin. Exceptions are hurricanes, monsoons, and typhoons, which must originate in the tropic zone, the area between latitudes 30°N and 30°S.

Noncyclonic storms produced by prevailing winds are identified by their accompanying winds. Examples of these storms are the gale, with 34- to 47-knot winds, and a full storm with winds of 48 knots and above. They are predictable and are not discussed here. Various other storms and severe atmospheric phenomena are explained in the following paragraphs.

TORNADOES

A tornado, one of the most destructive types of storms known, is a violent, whirling storm of small diameter (usually a quarter of a mile or less). A tornado travels across the country and leaves great devastation along a narrow path. It is known popularly as a twister or a cyclone in the central United States, where it occurs most frequently. A tornado has the following characteristics:

1. A heavy cumulonimbus cloud under which hangs a funnel-shaped cloud, marking the vortex, which may or may not touch the earth as the storm moves along.
2. Heavy precipitation accompanied by thunder and usually hail. A roar in addition to thunder accompanies the tornado cloud whenever it touches the surface of the earth.
3. Winds blowing spirally upward around the axis of the tornado cloud. Their speeds have been calculated to be as high as 300 miles per hour, and in rare instances even higher. Data from recent tornado studies indicates that wind velocities are in the range of 150 to 300 miles per hour. A large reduction of pressure in the center, caused by the spiraling of the air, seems to cause buildings in the path of the storm to explode.

4. The speed of the tornado over the surface of Earth is comparatively slow, usually 25 to 40 miles per hour. The length of its track on the ground may be from a few hundred feet to 300 miles. The average is less than 25 miles.

Along the West Coast of Africa, squalls accompanying thunderstorms are also called tornadoes, but have few of the qualities of the true tornado.

WATERSPOUTS

A waterspout is a small whirling storm occurring over the oceans or inland waters. Its chief characteristic, in a fully developed spout, is a funnel-shaped cloud extending from the surface of the water to the base of a cumulus-type cloud. The water in the funnel is confined mostly to its lower portion. Waterspouts usually rotate in the same direction as cyclones (counter-clockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere), but the opposite rotation is occasionally observed. They ordinarily are found in tropical regions, but may develop in higher latitudes, too.

Waterspouts are divided into two classes according to their origin and their appearance. One category is the true waterspout, in which the vortex forms in the clouds by the interaction of air currents flowing in opposite directions. This type of waterspout is similar to a tornado in aspect and formation. Pseudo-waterspouts, the second class, are of a different nature. A pseudo-waterspout originates just above the water surface in convectively unstable air and builds upward, frequently under clear skies. This type of waterspout has the same wind characteristics as the whirling pillars of sand and dust often seen on the deserts.

Waterspouts vary in height from a few hundred feet to several thousand feet, and in diameter from a few feet to several hundred feet. The highest waterspout on record was 5,014 feet, observed in South Wales, Australia.

NOTE

Waterspouts are less violent than tornadoes, but should be avoided.

SQUALLS

A squall is a wind of considerable intensity caused by atmospheric instability. A squall comes up and dies down quickly, and sometimes is accompanied by thunder, lightning, and precipitation. Often a squall is named after the special weather phenomenon that accompanies it. Thus, there are rain squalls, snow squalls, and hail squalls. Over the ocean, squalls are very common in the doldrums, where you may see several from your ship at the same time. Squall winds differ greatly in intensity, from moderately heavy to violent. A violent squall is capable of capsizing small ships when they are unprepared.

MONSOONS

Steady winds somewhat similar to the trades, called monsoons (of Arabic origin, meaning "season"), are found in the South China Sea and the Indian Ocean. The air over the land is warmer in summer and colder in winter than that over the ocean, producing a variance in atmospheric pressure. Seasonal temperature changes induce a seasonal character in the monsoon. The northeast (winter) monsoon usually blows in the South China Sea from October to April. It is known as the dry, or fair-weather, monsoon, although its force often reaches moderate gale proportions. The southwest (summer) monsoon normally occurs from May to September, and breaks heavily on some coasts Also known as the wet monsoon, it usually is accompanied by heavy squalls and thunderstorms and by an average rainfall that is much heavier than that of the northeast monsoon season.

HURRICANES

Tropical storms with continuous winds greater than 63 knots are called hurricanes. Hurricanes usually occur in the Atlantic, northeastern Pacific, and West Indies. Although their exact cause is not known, they soon dissipate over land areas and cold water, indicating that their existence depends somehow upon water vapor and warm temperatures, both of which are present in the doldrums. The whirling cyclonic wind apparently starts when warm, vapor-laden air is underrun and forced upward by convergence of the wind flow.

Once the storm develops, it normally follows the current of free air northwestward or southwestward until it arrives at the boundary of the adjacent high pressure region. Here, where the

prevailing winds turn eastward, the storm changes course, moves for some distance toward the pole, and then veers toward the northeast or southeast.

In the Northern Hemisphere, the track of a hurricane in the Atlantic or Pacific Ocean is northwesterly from its starting point in the doldrums. At the western edge of the high-pressure area, the storm usually veers to the northeast and either dissipates in the middle latitudes or takes the form of a less severe extratropical cyclone.

Hurricanes of the central South Pacific follow a similar track southward, moving west and south for the first branch of the parabola, then veering southeastward.

Typhoons and baguios of the western Pacific may follow a course similar to that of a West Indies hurricane, or they may expend their force on the South China Sea coast.

Figure 5-22 shows a typical track of a hurricane in the Northern Hemisphere, in the Atlantic. Figure 5-23 shows a hurricane track in the Southern Hemisphere, in the central Pacific.

TROPICAL STORMS

Currently, the term *tropical storm* is subdivided into three categories based on wind speed. They are distinguished as follows:

1. Tropical depression—winds less than 34 knots
2. Tropical storm—winds 34 to 63 knots
3. Hurricane/typhoon—winds greater than 63 knots

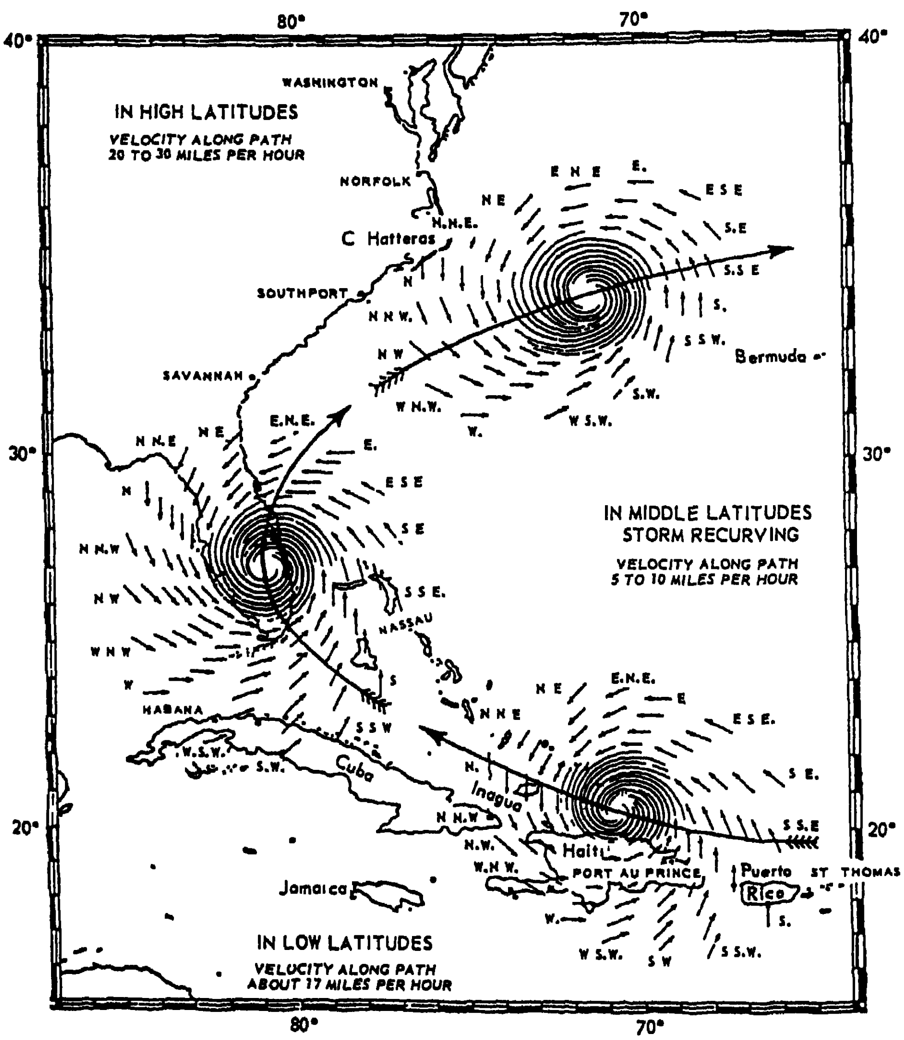


Figure 5-22.—Track of a tropical storm originating in the West Indies.

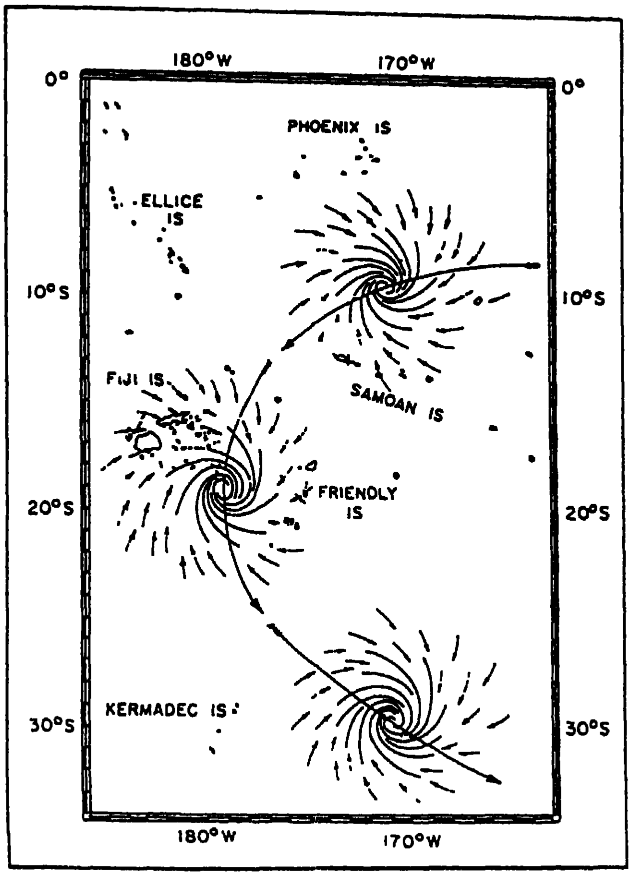


Figure 5-23.—Track of a tropical storm originating in the Southern Hemisphere, in the central Pacific.

Although the wind velocities associated with these storms are less than those in a tornado, the tropical storm covers hundreds of times the area covered by a tornado and can last much longer. Therefore, the total damage from a severe storm can be many times the damage from a tornado.

TROPICAL STORM WINDS

The tropical storm can be the most destructive of all weather phenomena. It begins in the doldrums, moves westward, them curves to the northeast in the Northern Hemisphere (toward the southeast in the Southern Hemisphere). (See figure 5-24.) The pressure at the center of a hurricane averages 950 millibars. (The lowest pressure ever recorded is approximately 890 millibars.) These storms vary in diameter from 60 to 1,000 miles. At their outer edges the wind velocity is moderate, but it increases toward the center, where velocities higher than 175 knots (200 mile per hour) have been recorded. Called the eye of the storm, the center is an area that averages about 14 miles in diameter. In this area the winds are very light; the seas are confused and mountainous; the sky often is clear; and drizzle may occur.

The elements of winds, temperature, pressure, humidity, and rain vary little in the different quadrants of a tropical storm. Winds increase from the outer limits to the eye of the storm; the temperature rises and the humidity falls at the center. Precipitation is in the form of showers at the outer limits, becomes heavier toward the center, and is usually heaviest in the right front quadrant. These storms are usually preceded by great wind-caused tides, called "storm surges", which cover the land and cause more damage than do the wind and rain of the storm itself.

Tropical storms with winds exceeding 63 knots occur throughout the world and are known by various names. They form over tropical oceans (except that none have been reported over the South Atlantic), but do not form over continents. They are common in the West Indies, ranging up the East Coast of the United States and into the Gulf of Mexico, where they are called hurricanes. Occurring in the western Pacific, off the coast of China, they are called typhoons. Off the west coast of Australia they are willy-willies, and off the Philippines they are called baguios. Through usage, all tropical storms occurring east of the 180th meridian in the Pacific are known as hurricanes.

Within the doldrums, where there are light and variable winds or no winds, rainfall comes in sheets, with frequent thunderstorms and squalls. This belt of baffling winds and rains is the breeding place of the majority of tropical storms.

The cyclonic winds of tropical storms in the Northern Hemisphere circulate counterclockwise. It is most important to remember this direction when it becomes necessary to maneuver out of the path of a tropical storm or hurricane. Study figure 5-22 and you will see that as you face the same direction the storm is moving, winds in the right, or dangerous, semicircle of the storm are circulating in such a way that they would draw a ship into that semicircle and into the path of the storm.

Figure 5-23 shows the Southern Hemisphere, where cyclonic winds circulate clockwise and the situation is the opposite of that just described. As you look along the storm track, you can see how winds in the right semicircle would tend to force a ship out of the storm's path and help her get behind the storm. Winds in the left semicircle would draw the ship into the track and blow it

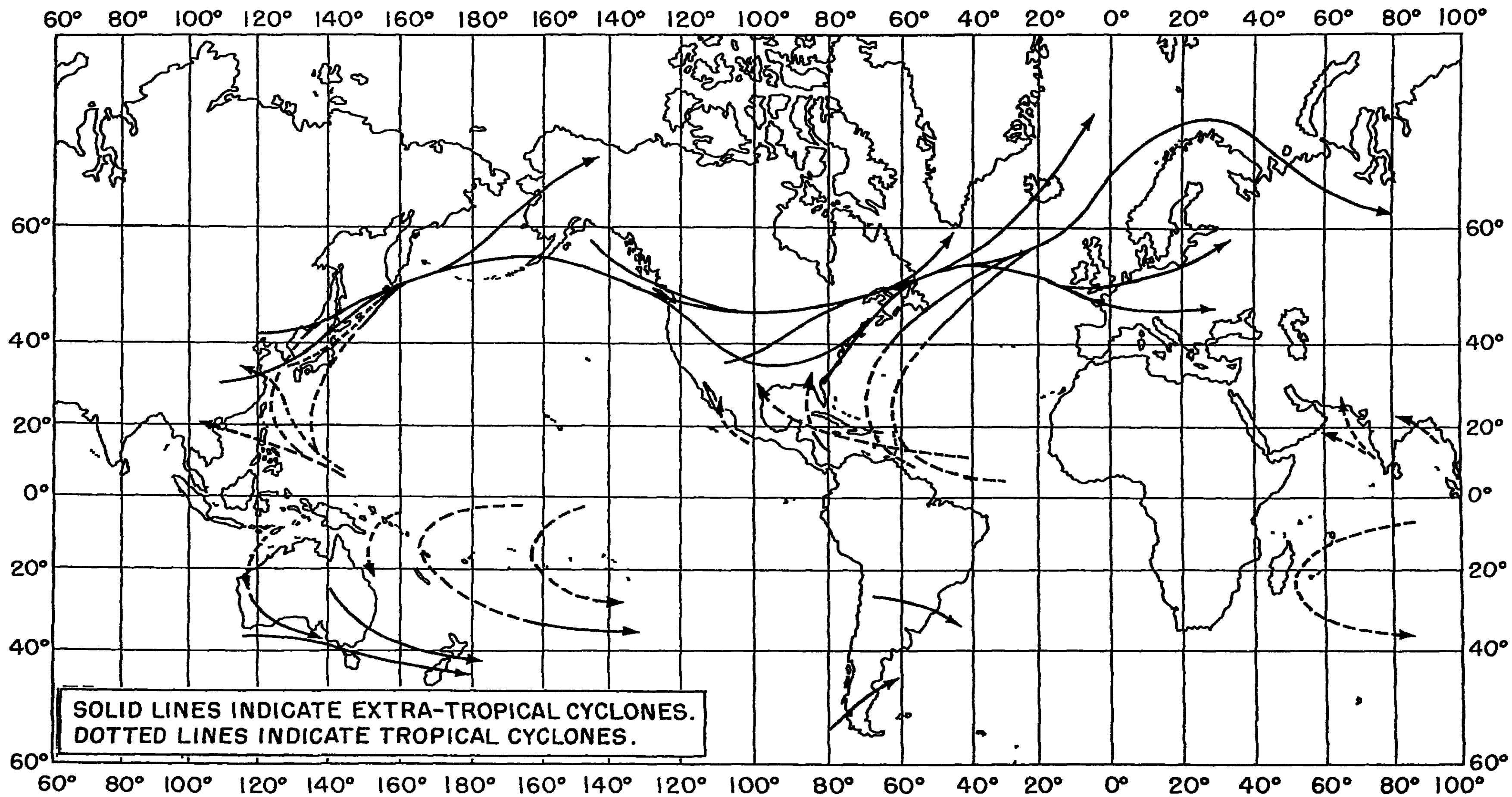


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Figure 5-24.—Tropical and extratropical storm tracks.

along with the storm. As you face the direction in which the storm is moving in the Southern Hemisphere, the dangerous semicircle is to your left, and the navigable semicircle to your right.

Maneuvering a ship in a hurricane consists mainly of determining whether she is in the dangerous semicircle and, if she is, finding the best method of working the ship out of the semicircle.

TROPICAL STORM APPROACHING

A tropical storm, as mentioned before, can form quite suddenly, and a ship may be in the storm before it receives any radio warning of the storm's approach. Navigators should know the signs that indicate the approach of a tropical storm.

During the hurricane or typhoon season, any interruption of the regular diurnal (daily) oscillation of the barometer should be considered a warning of an approaching change in the weather. Although the barometer is not absolutely reliable in this respect, its indication of changing weather should always be taken into consideration. Once a storm begins, the barometer indicates with considerable accuracy both the storm's speed of approach and your distance from the storm center.

A long, low swell rises well in advance of the area of violent winds. The direction of the swell, if unaffected by intervening land masses, indicates the bearing of the storm center. Light, feathery plumes of cirrus appear shortly after the swell begins, fanning out from a whitish arc on the horizon. Next, the sky becomes more densely overcast until the fearsome-looking dark mass of the true hurricane cloud appears on the horizon. The barometer begins a steady fall; the air becomes heavy, hot, and moist; and the wind begins to pick up. You may or may not hear the humming sound caused by the speeding up of the velocity of the wind. Fine, misty squalls of rain break off from the main cloud bank. These rain squalls increase to heavy showers, and finally to torrents at the center. The barometer starts falling rapidly; occasionally it becomes erratic. The seas begin to roll in mountainous waves, which can completely engulf a large ship. The photograph of USS *Pittsburgh*, figure 5-25, shows the destruction caused by a tropical storm.

DETERMINING BEARING OF THE CENTER

In the Northern Hemisphere, as you know, a cyclonic wind whirls in a counterclockwise

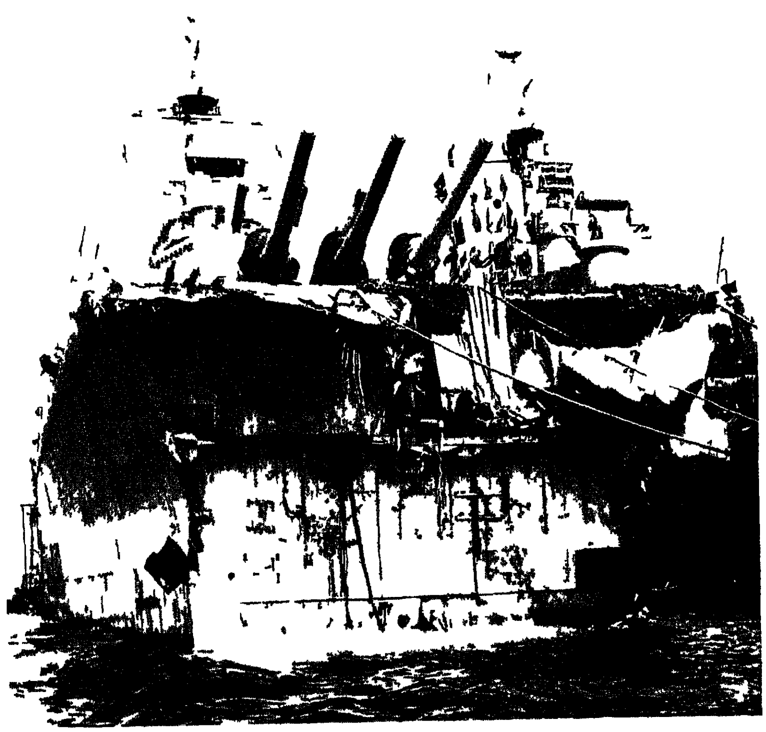

Figure 5-25.—USS Pittsburgh, bow having been ripped off in a typhoon.

direction. If you face the wind, the center bears about 113°, or 10 points, to your right. In the Southern Hemisphere the center is on about the same bearing to your left. It has been found that the storm center almost always bears close to 90° from the direction of movement of the storm's lower clouds. If this direction can be determined, the storm's center bearing can be indicated more accurately than by wind direction.

As the storm passes along its track, the wind hauls to one direction or the other, depending upon which semicircle you are in. In either the Northern or Southern Hemisphere, if the wind veers as you are facing it, you are in the right semicircle, which means that in the Northern Hemisphere it is the navigable semicircle. If the wind continues steadily from the same direction, you most likely are directly in the path of the center.

When you determine the bearing of the center, you must try to learn how far away it is.

Although the average rain fall of the barometer is not accurate enough to rely on completely, it gives you an idea of the speed with which the center is approaching. A tropical cyclone advances at 5 to 20 miles per hour. In the North Atlantic, speed of advance may reach as high as 50 miles per hour.

The following chart assumes a ship hove to in the track of the storm.

Average Fall of Barometer (in inches per hour)	Distance from Center (in miles)
0.02 to 0.06	250 to 150
.06 to .08	150 to 100
.08 to .12	100 to 80
.12 to .1	80 to 50

MANEUVERING IN A TROPICAL STORM

Once the bearing and distance of the storm center are determined, the next step is to plot the track along which the storm is expected to advance. Two or three bearings of the center, taken at intervals of 2 to 3 hours, should be enough to establish the probable track.

In the Northern Hemisphere, as stated previously, if the wind veers, the ship is in the dangerous semicircle; if it backs, it is in the navigable semicircle. If it continues from the same direction, with a falling barometer, the ship probably is in the path of the storm. This situation, of course, occurs only when the ship is laid to and kept on the same heading. When course and speed are changed so as to maintain a constant relative bearing between the ship and the storm center, the wind does not shift. In that event, only the barometer can tell you whether you are approaching or drawing away from the center. A vessel could get into trouble by overtaking the center of a slowly traveling storm. However, a decrease in the ship's speed might allow it to ride out the storm.

The general rules for maneuvering a ship in a tropical cyclone in the Northern or Southern Hemisphere are as follows:

NORTHERN HEMISPHERE

In the right, or dangerous, semicircle: Bring the ship around so that the wind is on the starboard bow, and make as much headway as possible. If obliged to heave to, do so head-to-sea.

In the left, or navigable, semicircle: Bring the wind on the starboard quarter and hold the ship on that heading. If obliged to heave to, do so stern-to-sea.

On track, ahead of the center: Bring the wind 2 points on the starboard quarter, and run on that heading for the left semicircle.

On track, behind the center: Avoid the center by the most practicable route, with due consideration that the storm eventually will curve northeastward.

SOUTHERN HEMISPHERE

In the left, or dangerous, semicircle: Bring the wind on the port bow and make as much headway as possible. If obliged to heave to, do so head-to-sea.

In the right, or navigable, semicircle: Bring the wind on the port quarter and hold the ship on that heading. If obliged to heave to, do so stern-to-sea.

On the storm track, ahead of center: Bring the wind 2 points on the port quarter, and run on that heading for the right semicircle.

On the storm track, behind the center: Avoid the center by the most practicable route, realizing that the storm eventually will curve southeastward.

SUMMARY

The Naval Oceanography Command is the agency that provides oceanograhic and meteorological support and services. Due to the magnitude and variety of tasks, NOMSS has been implemented to meet fleet and force commanders requirements.

Routine support and specialized services are routinely provided and, in particular instances, must be specifically requested. Among the services available are wind warnings, high sea warnings, WEAX, and OTSR. The primary source document for requesting services is NAVOCEANCOMINST 3140.1.

Weather charts, whether facsimiles or drawn, are used to forecast weather. Chart construction, proper use of symbology, and recognition of observation data (correct or incorrect), is necessary for interpretation and weather forecasting.

Winds are naturally occurring, but meteorologists have noted that particular wind patterns and effects consistently occur within certain latitudes of the world. The combined effects of winds and pressure areas can and do cause various types of heavy weather. Some examples are tornadoes, waterspouts, squalls, and hurricanes.

Tropical storms are known for their massive destructive force. The prudent mariner watches for signs, procures weather warnings and messages, and begins tracking tropical storms to determine not only their location, but their probable path. If your track and that of a storm cross or near one another, tropical storm maneuvering is paramount to your vessel's safety.

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APPENDIX I

GLOSSARY

BACK—Of the wind, to change direction in a counterclockwise direction in the Northern Hemisphere and a clockwise direction in the Southern Hemisphere; of a ship, to go stern first, or to operate the engines in reverse.

CANTENARY—The curve formed by a uniform cable supported only at its ends. Examples: tow cables; anchor chains.

CHORD—A straight line connecting two points on a course.

DEPERMING—The process of changing the magnetic condition of a vessel by wrapping a large conductor around it a number of times in a vertical plane, athwartships, and energizing the coil thus formed. If a single coil is placed horizontally around the vessel and energized, the process is called *flashing* if the coil remains stationary.

HAUL—Of the wind, to shift direction.

LOCAL APPARENT NOON (LAN)—Twelve o'clock local apparent time, or the instant the apparent sun is over the upper branch of the local meridian.

MAGNETIC EQUATOR—That line on the surface of Earth connecting all points at which the magnetic dip is zero. Magnetic equator is similar to and physically located near the geographic equator.

MOVREP—U.S. surface ship operational movement report.

NOMOGRAMS—A diagram showing, to scale, the relationship between several variables in such a manner that the value of one which corresponds to known values of the others can be determined graphically. Examples: Tidal graphs; set and drift graphs.

PERPENDICULAR—Intersecting at or forming right angles.

PITCHING—Oscillation of a craft about its lateral axis.

RHUMB LINE—A straight line on a Mercator projection chart, a segment (chord) of a great-circle track or bearing.

SUBNOTE—U.S submarine operational movement notice.

VEER—Of the wind, to change direction in a clockwise direction in the Northern Hemisphere and a counterclockwise direction in the Southern Hemisphere; of anchor chain, to pay or let out, as to *veer* anchor chain.

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